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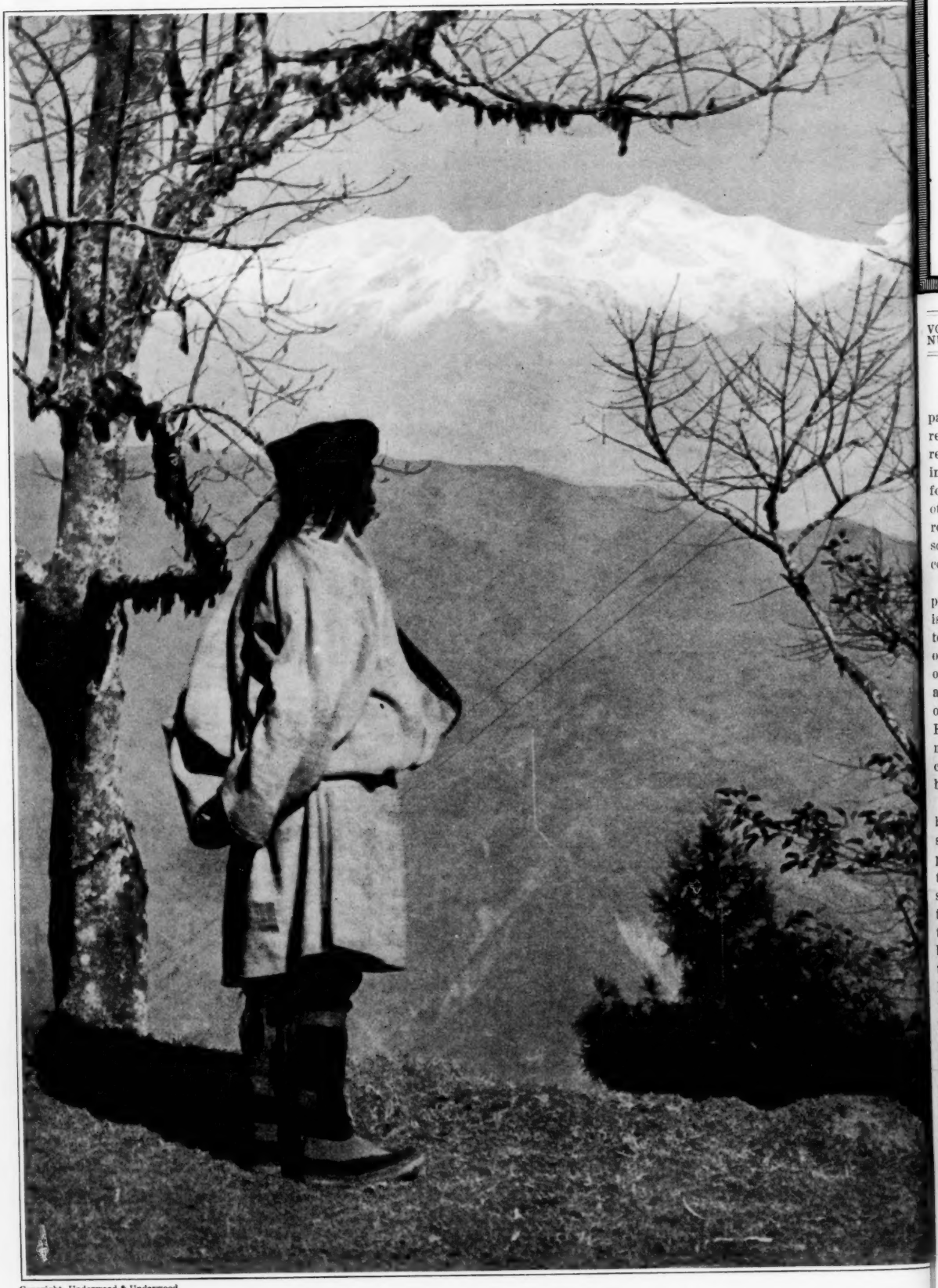

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THE WORLD'S GREATEST ADVENTURE—KANGCHENJUNGA, 28,156 FEET HIGH, THE SECOND HIGHEST MOUNTAIN IN THE WORLD (SEE PAGE 19)

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MR. MAXIM'S PAPER OF 1889

EINSTEIN'S Special Theory of Relativity, historically the parent if not logically the prerequisite of his General Theory, rests on a double foundation. On the one hand we have the realization, more or less clearly present for centuries though in part lost sight of by nineteenth century science, that uniform motion must of necessity be relative exclusively. On the other hand we have Einstein's startling assumption with regard to the constancy of the velocity of light, not relative to some universal medium but relative to all observers however conditioned.

That in the second-named pillar of his theory Einstein has presented something entirely foreign to previous human thought is plain enough. It would have been preposterous for anyone to suggest such an assumption prior to the development, out of the Michelson-Morley experiment and the Maxwell theory, of a group of experimental facts and theoretical considerations at variance with any other assumption which it has as yet occurred to human ingenuity to make. The date, 1905, when Einstein put forward his first paper on relativity probably marks the earliest moment when this extraordinary suggestion could have been received with sympathy by physicists or even by mathematicians.

If Einstein's second assumption is new and revolutionary, his first is well understood to follow more or less in the footsteps of classical science. From the time of the earliest philosophers men have realized with some degree of certainty that we can define motion only by means of something "assumed to be fixed"; and, with less certainty, have appreciated that the motion so defined is of significance only with respect to this chosen reference system. Now and then there has been someone who has ventured a little further than this in the direction of denying the significance of absolute motion. But such voices have been few and far between, and with the advent of the other hypothesis they became fewer and farther between; for it hardly seems possible to retain the ether and deny it the characteristics of a universal reference frame for absolute motion.

We reprint in this issue, from the SCIENTIFIC AMERICAN SUPPLEMENT of May 11, 1889, a paper by Hudson Maxim which, on the confession of its title, was devoted to the effort to prove that the ultimate particle of matter has real existence. The title did the text an injustice; it has a scientific content wider than the headline would suggest. In particular, we reprint it at this time chiefly because it contains what we believe to be the earliest unreserved statement of the universal relativity of uniform motion, with no loop-hole left for the man who would like to believe that after all there is, somewhere, something which if only he could find it he could use as a reference-frame for absolute motion. As explained in more detail on the editorial page of the SCIENTIFIC AMERICAN for July 2nd, we believe that, without detracting in any way from the credit due Einstein, Mr. Maxim may be conceded to have anticipated this phase of his philosophy *in toto*.

SHOOTING THE EARTH

FOR a number of years past a group of men in Christiania, Norway, have been trying to shoot the earth. They did not care what part of this planet they shot so long as they scored a hit. Yet strange as it may seem, they spent thousands of hours at this target practice without making a single score.

It would seem almost impossible to miss a bull's eye eight thousand miles in diameter, but large as it is, it proved to these marksmen a most difficult and illusive target. We may understand some of their difficulties when we learn that they located the gun from which they did the shooting, at a distance of ninety-three million miles from the earth, and for bullets employed projectiles so infinitely small that seventy-five million of them could be laid out in a single straight row within the space of an inch.

Instead of employing a muzzle velocity of three thousand feet per second which is high for a rifle bullet, the minute projectiles they used sped out the gun with a velocity many thousand times greater and this velocity was maintained by the projectiles throughout their course.

To be sure this was a mathematical target practice, or a sort of astronomical ballistics. It is just the sort of calculation that is performed in a plotting room to determine at what point of the heavens a gun must be directed in order to have its shell strike a target beyond the field of vision.

Some years ago the late Prof. K. Birkeland projected the theory that auroral lights are caused by a bombardment of cathode rays from the sun. These rays are formed by minute corpuscles which being electrically charged are diverted from their course by the magnetism of the earth and hence are confined within zones about the north and south poles. He demonstrated his theory by laboratory experiments. Then Prof. Carl Störmer of the University of Christiania undertook to plot the course of these minute projectiles. With the aid of a number of students, after a series of most laborious mathematical calculations, he succeeded in plotting the paths of a number of corpuscles but the particles would either glance off from the earth, or would describe loops around it without ever striking it. Then Professor Störmer reversed the process and undertook to work backward from particles which had reached the earth and determine their trajectories. In this he was finally successful.

Happily Professor Störmer knows how to write clearly and interestingly for the non-mathematical public and at our request he has prepared an article, fully illustrated with remarkable photographs of the northern lights and with models showing the paths of the cathode rays, which is published elsewhere in this number.

The Nature of Matter*

Principle of Force and Demonstration of the Existence of the Atom

By Hudson Maxim

Reprinted from the *Scientific American Supplement* of May 11, 1889

COEVIDENT with consciousness of our existence are certain truths.

Truth is the exact accordance with that which is, has been, or shall be.

Self-evident truth is that accordance with being which is too simple to require demonstration.

Complex truth is that accordance with being whose evidence requires demonstration.

A complex truth established upon self-evident truths is a concomitant certainty with the primary truths themselves.

There is no difference in truth. Self-evident truth is what, with all conditions necessary to its determination as absolute, is at once within consciousness of certainty. What truth is self-evident to one mind may not be so to every other. The greater the mind, the greater the truths that become self-evident. Some truths that are self-evident to the mind of a Newton, a Darwin, a Spencer, may be far beyond the comprehension of ordinary mortals. An axiom is any self-evident truth.

SELF-EVIDENT TRUTHS

Axiom 1.—A thing cannot, at the same time, be and not be.

Axiom 2.—That which exists as a composite whole, its parts, as units of the whole, also exist.

Axiom 3.—The whole is greater than any of its parts.

Axiom 4.—Every whole is equal to all its parts taken together.

Axiom 5.—If any part be taken from a whole, there remains such a part of the whole as has not been taken.

Axiom 6.—Division of a body is not annihilation of the body.

Axiom 7.—Nature extends without limit in all directions and contains all bodies, all space, all causes, and all effects.

Axiom 8.—No two solid bodies can occupy the same space at the same time.

Axiom 9.—An absolute solid completely fills the space occupied by its dimensions of extension.

Axiom 10.—No absolute solid can occupy more space than is equal to its dimensions of extension.

Axiom 11.—No absolute solid can occupy less space than is equal to its dimensions of extension.

Axiom 12.—An absolute solid cannot pass through the same space at the same time that it is occupied by another absolute solid. (Axiom 8.)

Axiom 13.—If an absolute solid be taken from a given space, there remains an absolute void of dimensions of extension equal to those of the solid body taken.

Axiom 14.—Motion is alteration of position or changing of place.

Axiom 15.—Force is any action between bodies which changes, or tends to change, their relative condition as to rest or motion.

Axiom 16.—There exists a certain something which we call matter.

Axiom 17.—There exists an attractive force between different portions of matter which we call gravitation.

ARGUMENT

Let us take the word "nature," as best suited to our use, and consider the term as embracing in its meaning all space, all matter, all causes, and all effects.

It is self-evident that nature must be either all an absolute void, or an absolute solid, or consist of both, perfect solids and void spaces.

Nature cannot be all an absolute solid, for in that case all motion were impossible. (Axiom 12.)

Nature, therefore, must be either all an absolute void, or consist of perfectly solid portions of matter and void spaces where matter exists not. (Axioms 9, 10 and 11.) One of these two alternatives must be true. (Axiom 1.)

Nature cannot be all an absolute void, for in that case all force and all motion were impossible; for if nothing existed, there would not be anything to move, or anything for force to act upon or between. And motion and force are as stated in Axioms 14 and 15.

Hence the only alternative left is that nature embraces spaceless solid units of substance and absolute void where substance exists not. For to demonstrate existence impossible except as claimed, of what is known to exist, proves the truth of the claim.

But let us argue this point a little further.

Let us take at the ordinary temperature of the air, what is termed a solid iron ball or sphere.

Now, it is self-evident that the sphere in question must be either all an absolute solid, or all an absolute void, or consists of both absolute solids and void spaces.

If we heat the sphere, we find that it expands, increasing its dimensions of extension in all directions; and on cooling again, we notice that it contracts to its former dimensions as it reaches its former temperature.

During these alterations in size we find that the weight or gravitative force of the sphere toward the earth remains unchanged. Hence the quantity of matter contained in the sphere is neither increased nor diminished. And, as an absolute solid could neither expand nor contract in size (Axioms 8, 9, 10), we know that the sphere in question cannot be all an absolute solid, but must contain void spaces.

We know that it cannot consist wholly of spaces, or else it would be nothing but void. (Axioms 1, 8, 9, 10.) Hence the sphere must consist of both void spaces and spaceless solids possessing certain dimensions of extension in length, breadth and thickness.

And the dimensions of extension of all the solid atoms plus the dimensions of extension of all the vacant spaces of any body are exactly equal to the dimensions of extension of the whole body; for the whole must be equal to all its parts (Axiom 4), and must require all its parts to complete the whole.

But it is argued that as we know nothing of matter except through force, force may be either a property of matter or matter be but a property of force.

It is self-evident that force is what it is claimed as being in Axiom 15, and hence cannot have being except in being what it is (Axiom 1)—the action or power of something exerted upon something, or action between two or more things or objects.

Therefore, as force can exist only as a condition of more than one thing, if we take away from the ultimate whole wherein force is considered, all of the parts except one, between which the exertion of force exists, we have one part left (Axiom 5), but no more. What, then, must that part be which is left?

The certainty that it exists (Axioms 1 and 5), the certainty that it cannot be force, the certainty that it can be nothing else, demonstrates that it must be absolutely solid substance. (Axiom 4.)

Let us now conceive of but one of these ultimate solid atoms as existing entirely alone in all space, assuming that it alone be all the matter or substance in existence.

*See editorial on preceding page.

It could have no motion in any direction, for space of itself without limit is without direction, and no place in space could have position relative to the rest of space—hence position and place as relative to but space are impossible, therefore, a single ultimate atom existing alone in space could have no motion, as it could not alter its position, having no position or place to change.

Hence, direction, distance, position or place are terms which relate to conditions of existence of more than one unit of existence or atom, excepting as relates to points within its own dimensions, and being an absolute solid, no point within itself can change its position relative to other points. Hence all motion were impossible with an ultimate atom existing alone in space.

The ultimate solid could have no axillary motion, as no point within its dimensions could alter its position relative either to other points in the solid unit or to space.

The conception of a centrifugal force from an axillary motion, as tending to separate the ultimate atom into parts, is untenable, for the ultimate atom being a perfect solid must also be absolutely unbreakable, as well as absolutely incompressible, as will be more fully shown further on.

A single ultimate solid existing alone in space could possess no attracting or repelling force or power—as there would be nothing for it to attract or repel.

Therefore position, place, force, and motion are conditions of existence of more than one ultimate atomic solid.

If we now conceive of another like ultimate solid atom as existing along with the first, an attracting force, or a repelling force, or both, according to distance, and the concomitant conditions of position and motion are possible.

But it is self-evident that as no change can take place in the ultimate solid, the only effect force is capable of producing, and the only force that is possible to exist, is the changing, or tending to change, the condition of the atoms as to rest or motion relative to one another.

Now, if a single ultimate solid existing alone in all space can possess no force, and in itself is incapable of undergoing any change; and if the addition of another ultimate solid along with it adds force, and the conditions of position and motion being the only conditions possible, if we add an infinite number of atoms we have an infinite force, and by infinite combinations of atoms we have infinite manifestations of force, but necessarily of the same force, as the only possible manifestation of force is in the change of the relative condition of atoms as to rest or motion, as all changes must occur outside of the atom, for the atom is of itself unchangeable.

ANSWERS TO ARGUMENTS AGAINST THE EXISTENCE OF THE ATOM

The principal arguments against the existence of the atom which I have seen are those advanced by Herbert Spencer and by Boscovich. Spencer, in his "First Principles," page 51, says: "Were matter thus absolutely solid, it would be what it is not, absolutely incompressible, since compressibility, implying the nearer approach of constituent parts, is not thinkable, unless there is unoccupied space between the parts. Nor is this all. It is an established mechanical truth, that if a body, moving at a given velocity, strikes an equal body at rest in such wise that the two move on together, their joint velocity will be but half that of the striking body. Now it is a law of which the negation is inconceivable, that in passing from any one degree of magnitude to any other, all intermediate degrees must be passed through. Or in the case before us, a body moving at velocity 4 cannot, by collision be reduced to velocity 2 without passing through all velocities between 4 and 2. But were matter truly solid—were its units absolutely incompressible and in absolute contact—this 'law of continuity,' as it is called, would be broken in every case of collision. For when, of two such units, one moving at velocity 4 strikes another at rest, the striking unit must have its velocity 4 instantaneously reduced to velocity 2, must pass from velocity 4 to velocity 2 without any lapse of time, and without passing through intermediate velocities; must be moving with velocities 4 and 2 at the same instant, which is impossible."

Spencer here bases his argument on what he supposes to be an immutable law of nature; that a moving body cannot pass from velocity 4 to velocity 2—that is, from a given velocity to a velocity half as great at the same instant.

Let us conceive of a body being projected perpendicularly from the earth in such wise that it shall ascend and descend in the same line. It certainly must stop at the point whence it begins to descend, and as it must move at some velocity until it stops, it must pass instantly from velocity something to velocity nothing, which is as great as from velocity 4 to velocity 2.

For, suppose the force of gravitation were instantly removed at the same instant that the ball was moving at its last degree of velocity, the ball would continue to ascend, and however slowly it moved, would travel a given distance, say twelve feet, in sufficient time, and if it moved with only half that velocity, it would travel six feet in the same time.

Now, a velocity of twelve feet in a given time is to a velocity of six feet in the same time as velocity 4 is to velocity 2. Therefore, to stop at all, a moving body must pass instantly from some velocity to some other equally less as from velocity 4 to velocity 2.

Again, suppose we were to project a body perpendicularly from the earth at the rate of a thousand feet per second.

From the moment it leaves the earth, the attraction of gravitation acting upon it, continually retards its motion until it stops; and each point throughout the line of its ascent must mark a degree in the reduction of its velocity, and hence it must sacrifice one degree of its velocity in attaining the height of each succeeding point throughout the entire line of its ascent until it comes to a stop.

Now, let us project a like body from the earth in the same manner and with equal force, but let us conceive of a gravitative force twice as great, which, acting upon the ascending body with double the retarding force exerted upon the first body, would bring it to rest at half the height attained by the first body.

Hence it must instantly lose twice as much velocity at each point of its ascent as did the first body. It must instantly lose twice as much velocity in the same time as did the other body when acted upon by the lesser gravitative force.

Therefore Spencer's argument amounts to nothing; for what he claims as impossible is so simple a truth that it may well be considered an axiom, as follows:

A moving body encountering a resisting force instantly loses such velocity as is exactly equal to the resisting force it at each or any instant encounters.

The theory of Boscovich is substantially that the constituents of matter are centers of force or ultimate units of force, points without dimensions which attract and repel one another in such wise as to be kept at specific distances apart. That is, that matter is but an attribute of force, instead of force being an attribute of matter.

We have already demonstrated this theory impossible. However, let us for argument's sake conceive of one of these force centers of Boscovich as existing entirely alone in all space, as we have already considered the ultimate solid.

Now it is self-evident that force as stated in Axiom 15, "is any action between bodies which changes or tends to change their relative condition as to rest or motion," and as a thing cannot be, and not be, at the same time, it is certain that force cannot be, where it can have no effect or tendency to induce change.

Now a single force center or unit of force existing alone in all space must still exist as force if it exist at all, and existing alone, there would be nothing but itself as an object of its action or tendency; and as force can exist only as action or tendency to induce change, the claim that a unit of force could exist alone is untenable, for it could so exist

only in action or tendency, and consequently negative the possibility of a unit of force existing alone, and the possibility of any truth in the force center theory.

But it is asked in argument by disciples of Boscovich if matter be composed of solid units of substance, what is it that holds together the parts of that body if it be not a cohesive force? And if one of these solid bodies were sundered by a sufficient force, what, but a cohesive force, would hold together a fragment into which it might thus be broken? And so on until we come to centers of force without any dimension.

Division of a body is not annihilation of the body, and no matter how far we carry division in thought, or how far conceive of possibility of carrying it, still a whole must be equal to all its parts taken together; and however infinitely small the parts into which a body may be divided, still the sum of the dimensions of extension of all the parts taken together must equal the dimensions of extension of the original whole; and thus any part, however small, must have dimensions of some extent.

The fact is, our ideas of breaking and separating of bodies are but our impressions from associated ideas. Could we possess infinite powers of vision, we would see that what we deem breaking of substance is in all instances but a moving apart of different substances, the same as the moving of a stone from the earth by lifting the stone, and that absolute fracture or breaking into fragments of absolutely solid substance is not in the course of nature or range of possibility.

We have come to reason inductively that all things must be breakable by the application of a sufficient force, and that some force must be sufficient.

Let us see about this. Suppose we conceive of an absolute solid, a perfect sphere in form and of sufficient size to be tangible to our senses.

Let us apply to every part of its surface a force "sufficient" to compress it. It is evidently now compressible. (Axiom 11.)

In the consideration of a force as tending to compress an absolute solid, all forces are equal to one another and hence all equal 0—thus the term sufficient is inapplicable, the same as no time could be sufficient to end eternity, or distance sufficient to extend to the end of space. Nothing could be sufficient to render an impossibility possible.

Let us reverse this force and let there be a force acting upon every point on its surface sufficient to pull an absolute solid asunder; is it not evident that it would be equally as unbreakable as incompressible?

It is self-evident that no force whatever, equally applied to every point of the surface of an absolute solid sphere could compress it. Suppose we reverse that force, and consider force in any degree of amount as drawing equally in all directions outward from every point of its surface, how and where could fracture occur? Being a perfect solid, its cohesive force or tensile strength, if considered in the light of a force or strength, must be absolutely equal throughout every point of its entire dimensions, hence such force could tend to produce no other effect than absolutely equal expansion throughout its entire dimensions. That is, it must expand so that no one point or portion shall be more solid or rarefied than any other—that is, it must expand and still retain itself a perfect solid, which is impossible. (Axiom 10.)

SUMMARY OF DEDUCED TRUTH

First.—All matter exists in ultimate atomic units of absolutely solid unchangeable substance.

Second.—With but one ultimate atomic solid existing alone in all space, all force, motion, or change of condition would be impossible.

Third.—With but two or three ultimate atomic solids existing alone in all space, attraction, or repulsion, or both, according to distance from one another, would be the only possible forces that could exist. And the only possible change that could be wrought by these forces in the condition of these atoms would be a change of their conditions as to rest or motion by changing their positions relative to one another. Adding any number of atoms adds no new force, neither makes any new force the more possible, but increases the possibilities of the same force directly as the squares of their numbers, and inversely as the squares of their distances from one another.

Fourth.—The sum of all the forces of all nature at the present moment is exactly that of the sum of gravitative force and of the momentum acquired by its ultimate atomic solid units in their nearer approach to one another, occasioning the passage of matter from a rarer to a denser form.

Fifth.—All events of all history and all phenomena, and all evolutions of organic and inorganic, animate and inanimate nature during all time, have been exactly those which have resulted from the sum of the combined forces of all the atoms in existence acting upon one another.

Sixth.—Every atom in existence follows a course mathematically exact—that which is determined for it by the combined forces exerted upon it of all the other atoms in existence. And every atom in existence follows a course as mathematically exact under the combined influences exerted upon it as do the heavenly bodies.

Seventh.—Could all the atoms in existence be instantly placed in exactly the same position relative to one another that they occupied just one thousand years ago, possessing the same acquired momentum they then possessed, every heavenly body would again pass through exactly the same change of position relative to one another that they have passed through during the last thousand years, and all would again at the end of one thousand years be in exactly the same positions that they now occupy. And the same with every earthly event, everything would reoccur in the history of men exactly the same, and all things reoccur exactly the same and in the same order as they have occurred during the last thousand years, and we should again all be here, the history of all our lives be the same, and we should all again be educated by the same influences which determine us to work our own destiny without changing the nature of a single atom or swerving one from its destined course.

There can be no effect without a cause, and there can be no cause which is not itself an effect of a preceding cause. Every effect is a cause for effects exactly equal to itself.

There can be no more effects in nature than are exactly equal to producing causes. And there can be no more causes for effects than is exactly equal to the effect to which nature owes those causes, which are the causes of those causes.

The ultimate atom is the unit of measure of power in all effects.

ELECTRIC DOUBLET THEORY OF GRAVITATION AND RADIATION

IT is suggested that gravitation may be an effect arising from fluctuations of the electric charges associated with the electrons and positive nuclei of atoms. It is assumed (1) that the ether contains an enormous number of electric doublets moving in all directions with the speed of light; (2) that each charged particle is continually both absorbing and emitting doublets at a rate proportional to its mass; and (3) that during the absorption and emission of each doublet the charge on the particle fluctuates. If these fluctuations exist, it is shown that the mean value of the force exerted by one charged particle on another includes, in addition to the ordinary electrostatic force, an attraction proportional to the product of the masses.

If we suppose that the doublets emitted by a particle possess available energy only when the energy of the particle changes, and that the effect of changing the energy is to produce periodic gaps in the emission of doublets with a frequency proportional to the amount of energy lost, we have a theory of radiation which is said to be compatible with the theories of Bohr, Planck and Einstein.—H. Bateman in *Phys. Rev.*, January, 1921. Abstracted through *Science Abstracts.*

Einstein's Theory of the Universe

The Hypersphere—a Universe Unbounded but of Finite Volume

By L. P. Eisenhart

Professor of Mathematics, Princeton University

WHEN Einstein applied his theory of general relativity to the paths of light, he came to the conclusion that the path of a ray of light passing near the sun would be bent toward it. When experiments, made in 1919, verified this prediction not only in fact but in amount, scientists began to believe in the theory of relativity. But when Einstein announced that, in accordance with the principles of relativity, the universe is finite and yet unbounded, people in general became interested and wanted to know what this meant.

The classical mechanics of Galileo and Newton rests upon the assumption that space extends indefinitely in all directions and that its properties are set forth in the plane and solid geometry of Euclid which we studied in school. It is also assumed that time and space are independent entities. We have been in the habit of thinking that matter is distributed throughout this space in all directions. When new stars at greater and greater distances reveal themselves as our telescopes become more powerful, we naturally become more convinced that our space is infinite in all directions and that there is matter everywhere in it. But is this conclusion in accord with the application of the Newtonian theory of gravitation to the universe as a whole?

When we speak of the mean density of the matter in a body we mean the quantity of matter which would be contained in a unit volume of it, if the matter were uniformly distributed throughout the body. Consequently the quantity of matter in a body is equal to the product of its mean density and volume. If the quantity of matter in a body is unchanged as its volume increases, the mean density necessarily decreases. An example of such a state of affairs is afforded by a balloon containing gas; when the gas expands enlarging the balloon, the mean density of the gas becomes smaller. Likewise the mean density of matter in the universe would be the quantity of matter in a unit volume of the universe, if all the matter were uniformly distributed. It will be necessary to consider the two possibilities, when the mean density for the universe is different from zero, and when it is zero. The latter would be the case if all the matter in the universe were finite in amount and were contained in a finite portion of it, the remainder of space being void of matter. The mean density of the matter in this finite portion would be different from zero for this finite volume, but the mean density of matter in the whole universe extending indefinitely in all directions would be equal to zero. For the product of a finite mean density and an infinite volume would necessarily give an infinite quantity of matter, which is contrary to the above assumption.

Suppose that we consider the matter in the universe distributed throughout it and the mean density to be different from zero. Let us consider now a very large spherical portion of the universe, and the behavior of a body at a point of its surface due to the attraction of the matter within, whose mean density is approximately equal to the mean density of the universe. In accordance with Newton's law of gravitation and a theorem due to Gauss, this body would be attracted by a force proportional to the product of the radius of the sphere and the mean density of matter. As the sphere became larger the force acting upon the body would be increased without limit and consequently also the velocity of the body. Astronomers have no knowledge of velocities of the magnitude which this would necessitate.

The above argument would not apply if the mean density of matter in the universe were zero. We have seen that such would be the case if all the matter in the universe were finite and were contained in a finite portion of infinite space, the remainder of space being empty. The objection to this hypothesis is that energy in the form of light would be radiated into the portion of space void of matter and would be lost, and consequently there would be a continual reduction of the energy in the universe. Again, the astronomer Seeliger, who was the first to call attention to the difficulties which arise when the Newtonian law of gravitation is applied to the universe as a whole, proposed the possibility of matter of negative density so that the mean density could be zero—an assumption which is not satisfactory.

Is there any reason for expecting the general theory of relativity to yield an acceptable solution of this problem? One of the fundamental principles of this theory is that the character of space is determined by the matter in it, and in fact the very existence of space is conditional by matter. There is no *a priori* assumption as to the character of space, that is as to the geometry of space. Its geometry is a practical geometry; it is determined by experience. All of us have been schooled to such an extent in euclidean geometry that most of us have come to think of only one kind of geometry. However, the geometers have been developing other kinds of geometry and in order to proceed further with the present subject we must consider certain of these ideas.

The plane geometry of Euclid and plane trigonometry deal with the properties of a plane involving measurement, that is, its metrical properties. Accordingly we say that a plane is a *two dimensional euclidean space*, meaning by two dimensional that any point in the plane is determined by its distances from two perpendicular lines in the plane, just as a point on a sheet of paper is determinned by its distances from two adjacent edges. This idea has been generalized to the whole of our space, which we call euclidean space of three dimensions, meaning thereby that any point of the space is determined by its distances from three mutually perpendicular planes, just as a point in a room is determined by its distances from two adjacent walls and the floor. These three distances are called the *coördinates* of the point. Any three quantities which determine the points of euclidean space are called coördinates. There are innumerable systems of coördinates which can be used.

Any cylinder in euclidean three space can be rolled out upon a plane, or is *applicable* to the plane. The lines along which shortest distances on the cylinder are measured, called its geodesics, become straight lines when the cylinder is applied to a plane; and the angle between two such lines is unaltered in the process. Hence the geometry on the surface of the cylinder is the same as for the plane. Accordingly we call the surface of a cylinder, or any other surface applicable to a plane, a *euclidean two dimensional space.*

A sphere is not applicable to a plane, and consequently the metrical properties of the surface of a sphere are different from those of a plane; we realize this when we recall the theorems of spherical geometry and the formulas of spherical trigonometry. Therefore we say that the surface of a sphere is a *non-euclidean two dimensional space;* that it is two dimensional is seen when we recall that any point on a sphere is determined by its latitude and longitude which are the coördinates of the point. In general any surface which is not applicable to a plane is a *two dimensional non-euclidean space;* its points are determined by two coördinates.

The theorems of spherical geometry are ordinarily derived by making use of the geometry of the euclidean three dimensional space in which we think of the sphere as lying. But the theorems which apply to the surface of the sphere itself can be obtained from a set of axioms or postulates, without refer-

ence to three dimensional euclidean geometry. We say that these metrical properties are intrinsic to the surface as such. It may be objected that these axioms presuppose knowledge gained from the consideration of the sphere as lying in euclidean three dimensional space. Consider, however, the problem of measurement upon the surface of the earth. We find that for sufficiently small portions of the earth the metrical properties of euclidean geometry can be used. But when measurements over a considerable portion of the earth are made this is no longer the case. On the earth lines of shortest distance, or geodesics, are great circles. The surveyor would discover, if he were not acquainted with solid geometry, that the sum of the angles of a large triangle is greater than two right angles, and that its excess over two right angles is proportional to the area of the triangle. Thus by measurement the metrical properties of a sphere can be found out. Any point P of the sphere is determined by its distance from a point O, and the angle between the great circle through O and P and some other great circle through O. In terms of these coordinates a formula for distance between any two points on the sphere can be established. From this formula, called the metric, other geometrical properties of the sphere can be deduced.

There is another essential difference between a spherical surface and a plane. All points of the former lie in a finite area and this area has no boundary in the surface itself, whereas all the points of a plane do not lie in a finite area, nor is there a finite area of a plane without a boundary in the plane.

The geometer has generalized the idea of euclidean space to euclidean spaces of any number of dimensions just as the three dimensional space is a generalization of the plane. Also he has generalized the non-euclidean spaces of two dimensions into non-euclidean spaces of any number of dimensions. Thus the geometer conceives of a three dimensional non-euclidean space lying in a four dimensional euclidean space which is a generalization of a sphere lying in our space as we have thought of it; he calls it a hypersphere, speaks of its radius, and considers it to be unbounded, just as we observe the surface of a sphere to be without bounds. The geometer can write down the equations for such a space and also the expression for distance, that is the metric of the space, from which the metrical properties of the space can be derived. However, in considering these metrical properties of the hypersphere it is not necessary for him to think of it as lying in euclidean four-space; that is, he can develop the geometry of a hypersphere intrinsically.

In the consideration of physical phenomena both time and space enter. In the classical mechanics these two entities are considered to be independent of one another, and until recently it was generally conceded that there is an absolute space and an absolute time whose intervals could be measured by different observers regardless of the relative conditions of these observers. However, in accordance with the theory of special relativity, the measurements of space-intervals and time-intervals involved in certain physical phenomena are not absolute, but depend upon the position and velocity of the observer. Moreover, what one observer interprets as a time-interval or space-interval another observer may interpret as involving both space and time. Hence it becomes necessary to treat space and time together, so that in considering physical phenomena we speak of a space-time world which is four dimensional; it depends upon four coördinates. Einstein formulated the principle that physical laws must be expressed in a form not depending upon a particular observer; or as the mathematician puts it, physical laws must be expressed in a form invariant with respect to the system of coördinates used.

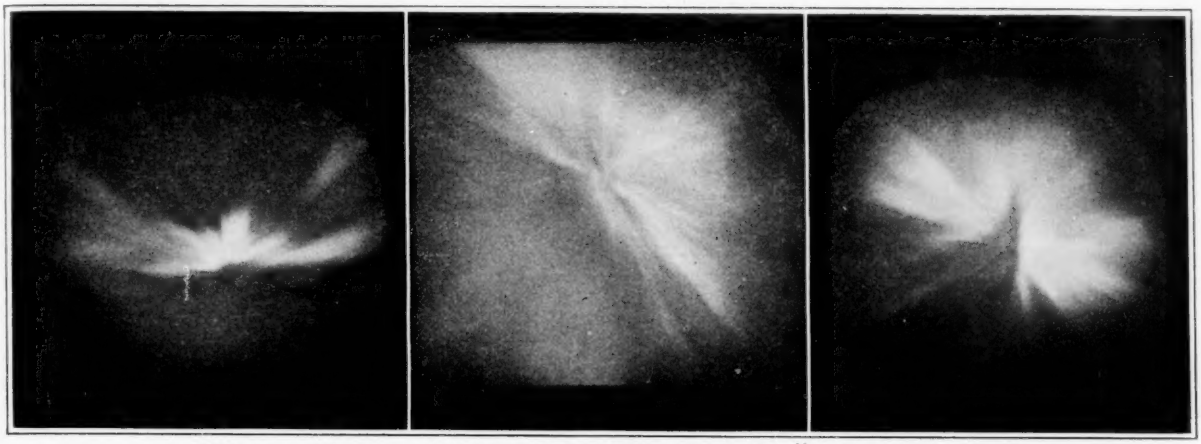
The general theory of relativity embraces all kinds of physical phenomena and makes use of the idea of a space-time world of four dimensions. The equations are expressed in a form invariant with respect to the system of coordinates used. The theory distinguishes between a gravitational field and matter, the latter embracing everything except gravitation; that is, matter includes electro-magnetism. Ordinarily the coördinates of space are not distinguishable from the coördinate of time. However, it is possible to distinguish between these elements in the case of planetary motion about the sun. In this case the equations of motion of a planet differ little from those obtained by the Newtonian method, but this difference accounts for the discrepancy in the motion of the perihelion of Mercury discovered by Leverrier.

When one considers the space in the neighborhood of the sun in which the planets move, it is seen from the metric of the space, obtained from the Einstein equations, that its metrical properties are those of a non-euclidean space of three dimensions. Einstein holds that the metrical character of the space is determined by the matter in the sun; that the space differs from euclidean space because of this matter. Accordingly he predicted that light passing through this space would not move in a straight line, but would be bent toward the sun.

As stated above, the equations of general relativity are applicable to any physical phenomenon. It is natural, therefore, to ask what information these equations give as to the metrical character of the universe as a whole. Although Einstein recognized the fact that matter is not uniformly distributed throughout space, he felt that by assuming a uniform distribution of mean density different from zero, he could get an approximate idea of the metrical character of space. On the assumption also that the motion of matter is very small as compared with the velocity of light, he was able to differentiate between the coördinates of space and the coördinate of time. When the equations of general relativity were made to conform to these conditions, it was possible to arrive at a unique conclusion as to the metrical character of physical space as a whole. The interpretation of the result by a geometer is as follows: The universe of physical phenomena is a hypersphere; its radius depends upon the mean density of matter in the universe and the space is of finite volume; the universe is not bounded just as the surface of a sphere does not have any boundary in the surface itself.

It may be all right for the mathematician to say that he can develop his imagination so as to speak of a hypersphere as a reality, but how about the physicist and the man who is concerned only with the realities of experience? Einstein lays emphasis upon practical geometry, the geometry of experience. He insists that we must not make an *a priori* assumption concerning the metrical character of space, but that we must be guided by the results of measurement. The purpose of any physical theory is to give a mathematical formulation which agrees with experiment, and from which predictions can be made concerning phenomena which have not yet been tested by experiment or which at present are beyond the range of experiment. Our present knowledge of the masses and special distribution of the fixed stars is not sufficient for us to determine with exactness the mean density of the universe, the knowledge of which is essential to the testing of the above results. We feel sure that the mean density is very small. On assumptions as to its magnitude, we can readily calculate the radius of the hypersphere. But as yet we must admit that these are assumptions. When definite knowledge of the magnitude of the mean density comes into our possession we can determine by physical measurement whether we must revise the conception of our space which has been drilled into the human mind for centuries. It was difficult to convince mankind that the universe is not geocentric. There is no reason to suppose that if experience demands it, the mind of the future will not develop the capacity to think of a finite and unbounded universe.*

*For the mathematical treatment of this subject see Einstein, Kosmologische Betrachtungen zur Allgemeinen Relativitätstheorie, Sitzungsberichte der Preussicher Akademie der Wissenschaften, Feb., 1917; the subject was treated by Einstein also in an address before the Prussian Academy, January 27, 1921, entitled Geometrie und Erfahrung, and in his Princeton Lectures, which will be translated into English and published by the Princeton University Press.



FIGS. 1-3. AURORAL CARONAE PHOTOGRAPHED FROM BYGDÖ, NEAR CHRISTIANIA

Fig. 1 was taken on March 22, 1920, at 7 h. 44m. P. M., Greenwich time: Fig. 2 was taken at 1h. 5m., and Fig. 3 which shows a corona of wonderful blue color was taken on the morning of March 23

The Aurora Borealis

A Mystery of Nature, Elucidated During the Course of the Last Few Decades

By Prof. Carl Störmer, of Christiana, Norway

ON March 22nd, 1920, there appeared over the greater part of the earth a display of northern lights, the form and beauty of coloring of which were unique, and which aroused the keenest attention among all investigators. In the United States of America it was observed at one hundred places, scattered over the country from the eastern States right to the west of California. Simultaneously the southern lights appeared in the southern hemisphere, being observed, for instance, in Australia. This display of northern lights, which also appeared in great splendor in Europe, was observed by my assistants and myself from a number of stations in southern Norway. These stations were connected with each other by telephone, and provided with cameras so that many hundred successful photographs were taken in the course of the night. As they were taken simultaneously at several stations, the height and situation of the northern lights can be calculated with accuracy. It appeared that on that night the rays of the northern lights reached quite exceptional heights, between 500 and 600 km. above the earth.

Figs. 1, 2 and 3 show photographs of auroral coronæ taken with an exposure of a few seconds from my main station at Bygdö, near Christiania.

By request of the Editor of THE SCIENTIFIC AMERICAN MONTHLY, I will give in the following a short survey of the investigations which I have undertaken in recent years, in order to explain the nature of the northern lights.

THE PROBLEM OF PHOTOGRAPHING THE NORTHERN LIGHTS. RESULTS OF THE PHOTOGRAPHIC CALCULATIONS OF HEIGHT

As all usual observations of the northern lights are more or less subjective and unreliable, it is of the greatest importance to obtain an objective method, and the only reliable one is in the present case photographic. For many years the problem of photographing the northern lights resisted all efforts. It was not until 1892 that Brendel succeeded in obtaining a fairly serviceable picture by an exposure of 7 seconds during a stay at Bossekop in the north of Norway. More pictures with short exposures were not published, until in 1909 I commenced systematic investigations in order to solve the problem. By the use of a small cinematograph lens with a

FIG. 4. NORTHERN LIGHTS TOWARD THE WEST, AT BOSSEKOP, FEBRUARY 28, 1913

FIG. 5. NORTHERN LIGHTS IN THE EAST, AT BOSSEKOP, MARCH 3, 1910

25 mm. aperture and a focal length of 50 mm. and Lumière *etiquette violette* plates, I succeeded in obtaining serviceable pictures with exposures of a few seconds, and in consequence I undertook two northern lights expeditions in 1910 and 1913 to Bossekop, in order to apply photography to the study and measurement of altitude of the northern lights. Bossekop, which is situated near Alten Fiord, 80 kilometers south of Hammerfest, is a classical spot for the investigation of the northern lights, and in the course of time has been visited by many scientists.

FIG. 6. THE CAMERA USED IN PHOTOGRAPHING NORTHERN LIGHTS

On these expeditions my assistant meteorologist, B. J. Birkeland, and I took many hundred successful photographs, of which a few will be reproduced here.

Fig. 4 shows a northern light display in the form of a multiple band, which extended from west to east above the zenith, with a beautiful blue-white color. The star Procyon will be seen in the center of the picture.

A beautiful yellow-green auroral band with bundles of rays will be seen in Fig. 5. These bands or draperies are very remarkable; they may have a length of many hundred kilometers.

Fig. 6 shows one of the cameras which were used on the expedition of 1913. To the left will be seen an arrangement whereby the image of an illuminated watch was photographed on the plate simultaneously with the northern lights. It was thereby possible to read the time direct on the plate and it was unnecessary to take time observations during the work.

This arrangement was particularly useful when the northern lights developed in great beauty. The pictures could then be taken quickly one after the other with registration of time for each picture.

We also successfully employed a cinematograph, and obtained series in which each picture was illuminated for about 4 seconds. Part of a series of this kind, taken in 1913, is seen in Fig. 7.

However, of considerably greater interest was the method, which I introduced for the first time on my expedition in 1910, for the photographic measurements of the altitude of the northern lights. The method is as follows:

From two stations at a distance (of about 30 km.) from each other, and connected by telephone, the northern lights are photographed after orders by telephone, both cameras being directed toward the same star. From the different positions of the northern lights on the plates, the altitude above the earth can be estimated, since the situation and the time are known.

As early as in 1910 there were obtained in this way a series of reliable calculations of altitude, and in 1913 the work was continued under considerably improved conditions. The result was no fewer than 2,400 determinations of altitude, which showed that the northern lights do not extend lower down in the atmosphere than about 87 km., and that the bulk of the northern lights and those with the greatest intensity of light occur between 95 and 120 km. Some forms, however, particularly the summits of the auroral rays, lay considerably higher, *i.e.*, more than 300 km.

We will here describe only one of these photographs.[1]

The photograph depicts a beautiful yellowish-green auroral drapery toward the west, and the planet Venus is seen in the middle of the picture, to the right slightly obscured by a cloud. On account of the small altitude of the cloud the latter is far beyond range of vision in the picture to the left, while the northern lights, the lower edge of which lay at a height of about 100 km., are only slightly displaced in relation to Venus. The lowest point of the pictures was situated at a distance of about 700 km. above a region half way between Norway and Greenland.

In recent years the same method has been employed in southern Norway. From my main station at Bygdö, near Christiania, I have had telephonic connection with a number of secondary stations, at distances varying from 26 to 250 km., and a large amount of material,[2] consisting of about three hundred simultaneous auroral photographs, was obtained during the lears 1916-1921. In addition, a number of characteristic single photographs were taken, a few of which I here reproduce.

On the night between the 7th and 8th of March, 1918, a beautiful display of northern lights was observed both in Europe and in America. It began with an auroral arc in the north as shown in the illustration, and later on at about 1 o'clock (Greenwich time) there came beautiful rays and a corona formation. See Figs. 10 and 11.

We will not enter into further details regarding the results of the photography of the northern lights, but will proceed to give as popular an explanation as is possible of the nature of the northern lights.

EXPLANATION OF THE NATURE OF THE NORTHERN LIGHTS.

As early as the year 1881 Goldstein formulated the idea that the sun sends out into space, streams of particles loaded

[1] A complete account of the expedition of 1913 will soon appear in print in the *Geofysiske publikationer* (Christiania).

[2] Of these only a few of the specially interesting results have been prepared and published.

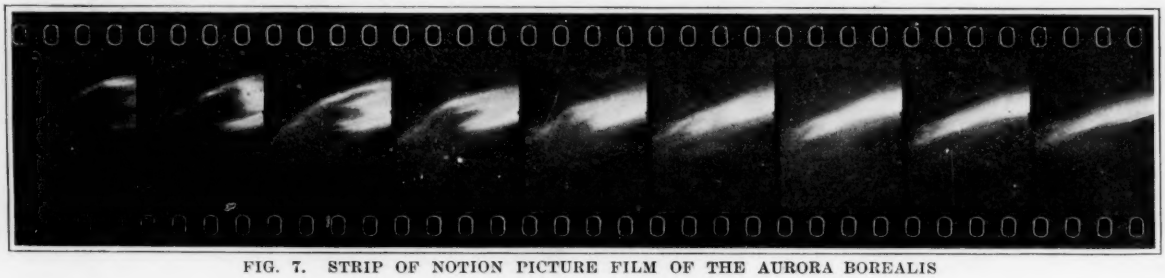


FIG. 7. STRIP OF NOTION PICTURE FILM OF THE AURORA BOREALIS

with electricity, which possibly cause electric and magnetic phenomena on the earth.[3] Later on, in 1893, Adam Poulsen, the Danish meteorologist, put forward the theory, based on his observation of the aurora borealis in Greenland, that the phenomenon is due to cathode rays. According to Poulsen's opinion these rays were formed in the upper strata of our atmosphere.

My deceased colleague, Professor Kristian Birkeland, however, by his series of remarkable experiments, was the first to give a reliable basis to the theory that the aurora borealis is caused by electric rays from the sun.

In 1896 he discovered the highly interesting effect of a magnetic pole on a beam of rays, viz: that of concentrating them to one point like the concentration of rays of light by a lens. This discovery suggested to his scientific mind the possibility that the earth, which is in reality a huge magnet, might in like manner concentrate cathode rays or similar electric rays from the sun, toward the southern and northern aurora borealis zones. Having adopted this suggestion, Birkeland tested it by decisive experiments.

In a large vacuum glass jar he suspended a small magnetic sphere, and directed the cathode rays toward it. This remarkable experiment was carried out in 1901.

While the sphere was still unmagnetized, the cathode rays touched only one-half of the sphere, upon which they distributed themselves like a uniform light, but as soon as the sphere was magnetized the phenomenon assumed a quite different character. The cathode rays distributed themselves in horn-like bundles of rays, the points of which touched two ring-shaped zones, one around each pole, and produced there illuminated patches distributed around these zones. Thus we obtained an experimental production of the belt of northern lights and the corresponding belt of southern lights. See Fig. 12.

Based on this experiment, and also on the results of his aurora borealis expedition in 1899-1900, Birkeland formulated his first aurora borealis theory, viz: that this phenomenon was the effect of secondary cathode rays, originating from vast systems of electric currents in the highest strata of the atmosphere, these systems of currents being formed by cathode rays from the sun.

Later on, however, he amended this theory in so far as he came to regard the aurora as directly caused by cathode rays from the sun. This new explanation of his was hinted at as a possibility in his treatise of 1901, and was further developed in the second part of his work, "The Norwegian Aurora Borealis Expedition, 1902-1903," which was completed in 1913.

About the beginning of the year 1903 I became deeply interested in Birkeland's remarkable experiments, and being

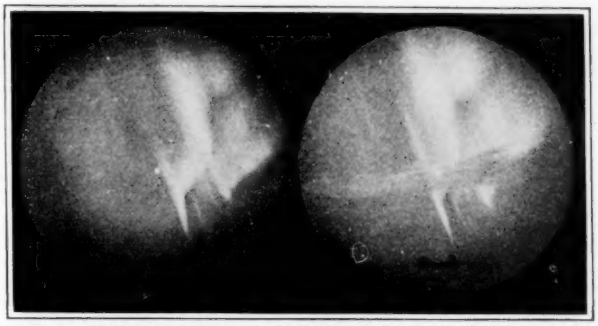


FIG. 8. PHOTOGRAPHS OF NORTHERN LIGHTS WITH PLANET VENUS IN THE BACKGROUND

Taken simultaneously from Bossekop and from Korsnes 27 kilometers north of Bossekop

a mathematician, I began to wonder whether it would be possible by purely mathematical methods to obtain not only the details of Birkeland's experiments, but even the essential characteristics of the nature of the aurora phenomena.

I started at once to work at the problem, and my first results were published in a treatise in the year 1904. In this work I succeeded in pointing out theoretically several matters of importance: First an explanation was found of the fact that the auroras are generally confined to the Arctic and Antarctic zones, and also an indication of the possible explanation of aurora arcs and curtains. It was found that a beam of parallel cathode rays emanating from the sun and descending into the atmosphere was bound to become situated in a long

[3] Vegard has found that the Italian astronomer Donati had a similar idea in 1872.

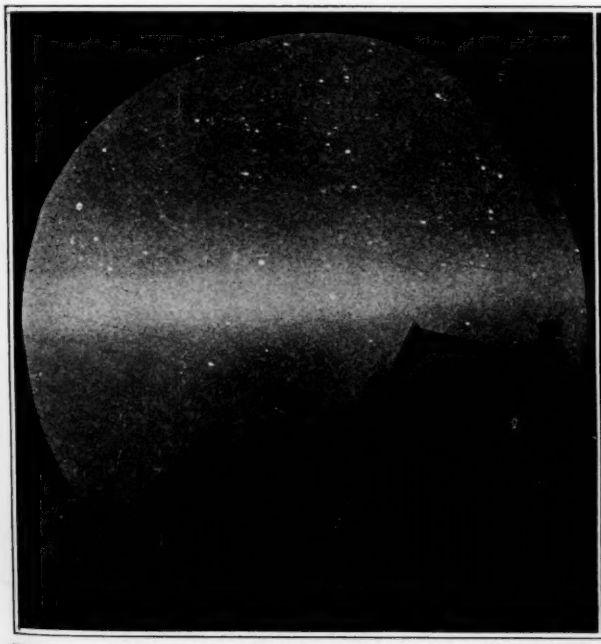


FIG. 9. AURORAL ARC PHOTOGRAPHED AT BYGDÖ ON THE NIGHT OF MARCH 7-8, 1918.

Perseur, Andromeda and Cassiopeia may be seen in the background

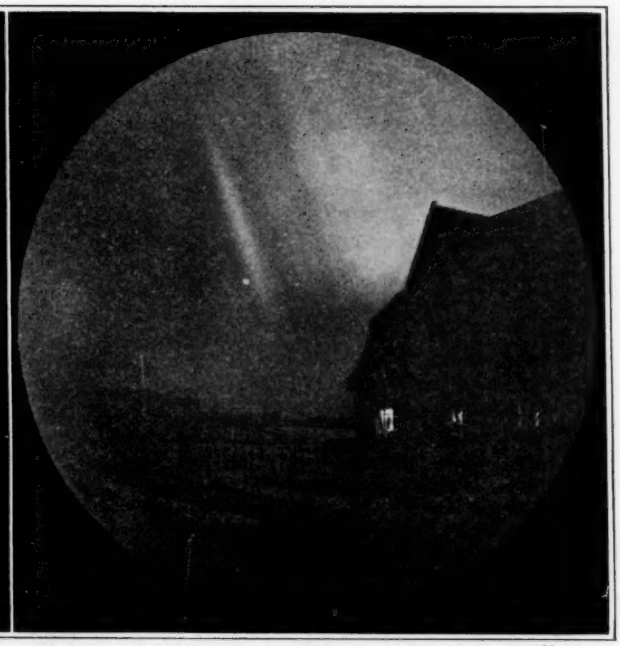


FIG. 10. AURORAL ARC PHOTOGRAPHED AT BYGDÖ ON THE SAME NIGHT

In the background may be seen the star Procyon

narrow area, limited by magnetic lines of force and extending in the direction of magnetic east-west. Rays diffused over this area would then cause arcs or curtains.

For further progress in this direction there was nothing left but a series of extensive calculations in order to integrate the differential equations of the problem numerically—as the technical phrase runs.

FIG. 11. AURORAL CORONA WITH THE GREAT BEAR IN THE BACKGROUND. TAKEN ON THE SAME NIGHT AS THE TWO PRECEDING

This vast undertaking was subsidized by the Nansen Fund, and extended over some years. In fact, the work absorbed something like 5,000 hours and a number of the students at Kristiania University have taken part in it from time to time.

I will endeavor to give a somewhat popular explanation of the objects in view.

The starting point of the theory was that electrically charged particles—the so-called corpuscles—emanate from the sun, and on their way through space approach the earth and are influenced by the latter. Thus the problem was to ascertain by calculation how this emanation of the corpuscle from the sun would have to take place in order that the corpuscle should hit the earth—and this calculation had to be performed for each and every position of the sun and the earth mutually.

The problem may be compared to that of calculating the trajectory of a cannon ball, the cannon being placed on the sun, the target being the earth, and the electrically charged corpuscle the ball. But the problem differs very much indeed from the simple trying of a new gun.

First of all the distance is immense. Fifteen million kilometers is so long a path that a cannon ball with a speed of 1,000 meters per second would need five years to travel the whole distance. To make up for this, however, the speed of the particle is very considerably greater than that of the cannon-ball, being several tens of thousands of kilometers per second: finally the projectile in our problem is infinitesimally small as compared with a cannon ball—measuring at the utmost a three-millionth part of a millimeter in diameter.

There is also another essential difference. The forces influencing the flying ball in a gun trial are gravity and the resistance of the air. In our problem, the corresponding influence is the effect of the earth's magnetism, because the particle is electrically charged. This influence is most peculiar, inasmuch as it does not check the speed of the particle, but consists only in a deflection at right angles to the direction of its path.

Higher mathematics, however, teach us how to master both problems. The trajectory may be found by careful calculation, and if we spend time freely the goal will at last be reached, though our progress be slow and our path uphill. In a popular article like the present I cannot specify in detail either the mathematical theory or the methods of calculation devised for the occasion, and I must content myself with showing the pictures of trajectory models.

We first calculated groups of trajectories from the sun corresponding to particles shot out in various directions toward the earth. The difficulty was to aim correctly so as to make the particle strike the earth. Most often we missed. The particle approached the earth but glanced off without hitting. Some few times the particle came fairly near, and approached the earth in a spiral path, coiling itself backward again without striking. At other times the particle would revolve round the earth far outside the path of the moon, later on returning inward in most remarkable loops.

In Fig. 13 we see a large cotton thread model of a series of trajectories. The earth is in the center, but I have made its size out of proportion. Several features are worth noticing. First note how the particles on the right side are flung sharply outward and upward and how those to the left side, the afternoon and night side, turn round the earth.

None of the trajectories here depicted reach the earth. It was not until it occurred to me to calculate backward from the earth to the sun, that at last we caught the trajectories that hit. More than 1,200 working hours were occupied in the exact calculation of these trajectories. You see some of them in Fig. 14.

A remarkable feature of these trajectories is the fact that they may turn round the earth and descend on the night side opposite the sun, corresponding to the fact that the aurora borealis may occur at night.

In Fig. 15 we see how well the calculations correspond with Birkeland's experiments. The places where the surface of the sphere has illuminated patches, agrees with the places of descent for the trajectories calculated.

By the aid of this mathematical theory a number of auroral phenomena are explicable, in particular, the formation and occurrence of the zones of aurora borealis and the characteristic arcs and draperies, also, the auroral rays and their direction. We cannot here enter into particulars,

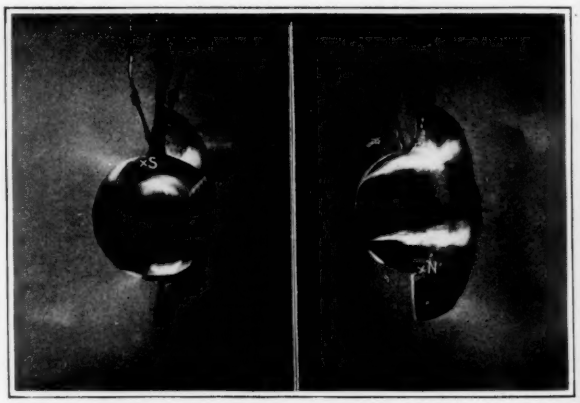


FIG. 12. ILLUMINATION OF THE MAGNETIZED SPHERE PRODUCED BY CATHODE RARS

To the right the sphere provided with a screen S indicates one of the magnetic poles

but must refer to the detailed report which is to be found published in "*Terrestrial Magnetism and Atmospheric Electricity*" for March and September, 1917, Washington.

Much still remains to be done. Thus in order to make clear the connection between magnetic storms and the aurora borealis, I showed, in 1911, that one effect of cosmic current systems of electric particles in the space around the earth, is

that they can draw the aurora southward, while at the same time magnetic storms are noticed all over the world.

Another problem is the path and illuminating effect of the rays during their passage down through the atmosphere. *That which we call the aurora borealis is precisely the light*

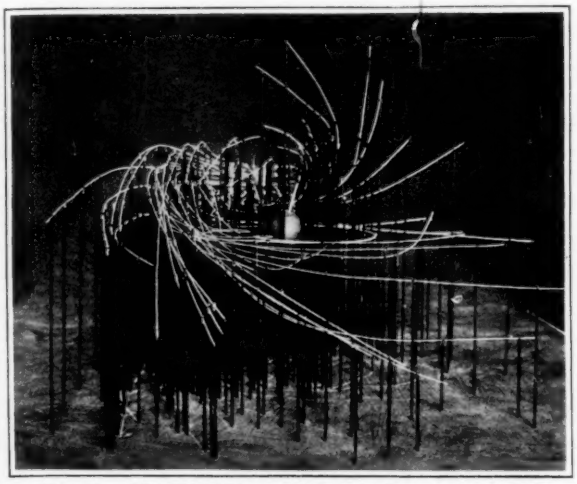


FIG. 13. TRAJECTORIES APPROACHING A MAGNETIC SPHERE FROM BEHIND. RESULT OF MATHEMATICAL CALCULATIONS

produced by the electric rays under the resistance of the atmosphere. The calculations concerning this phenomenon have, as regards the straight paths, been carried out by Lenard, Vegard and myself. As regards the *curved paths* (corkscrew spirals round the magnetic lines of force) the calculations are far more difficult, but I have succeeded in carrying them out. A work of considerable size on this subject is at present being printed.[1] The results show that it is thereby possible to explain a series of new details regarding the aurora borealis and at the same time they give *information regarding the composition of the atmosphere at greater altitudes.* For the last question, however, a study of the spectrum of the aurora borealis at various altitudes will be of decisive importance, and this will be one of the great tasks of the future in auroral research.

For solar physics, too, auroral research will be of import-

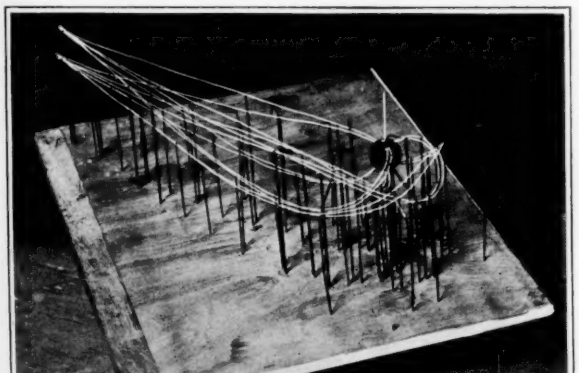


FIG. 14. SOME TRAJECTORIES HITTING THE AURORAL ZONES OF THE EARTH

ance, for the electric rays emanate from the solar atmosphere, and will therefore be able to provide us with information concerning the physical condition of the sun.

[1] In *Geofysiske publikationer* (Christiania).

THE DISTRIBUTION OF LAND AND WATER

MR. H. F. REID presents in a recent number of the Proceedings of the American Philosophical Society an interesting paper on the Distribution of Land and Water on the Earth.

The shapes of the various continents and seas, their relative areas, and their dispositions with regard to each other, says Mr. Reid, have always been attractive problems for geographers; and a number of characteristics have been formulated.

1. The earth can be divided into two hemispheres in such a way that nearly all the land is concentrated in one hemisphere, and the other is nearly all covered with water.
2. The land is everywhere opposite the water.
3. The land is concentrated around the arctic regions, and the water around the antarctic regions. The land sends three projections southward and the oceans three northward.
4. The continents are roughly triangular in shape, pointing southward. The oceans are roughly triangular in shape, pointing northward.
5. The continents are divided into a northern and a southern group by mediterranean seas, and the southern group is offset toward the east.

The antipodal relation of land and water has been until recently, says Mr. Reid, an absorbing though baffling mystery, with no threads leading to its solution. But the matter turns out to be rather simple, after all. It can be shown that nearly all the characteristics enumerated above are comprised in the following: The land area of the earth is a loosely connected, and deeply dissected area, about five-sixths of which is con-

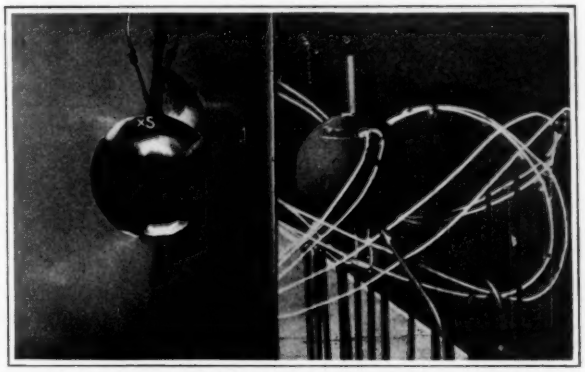


FIG. 15. REMARKABLE AGREEMENT BETWEEN THEORY AND EXPERIMENT

centrated in one hemisphere, whose pole lies about half way between the equator and the north geographic pole. And the position of this land area on the earth has no relation to the earth's equator and axis of rotation. So far as the antipodal relation of land and water is not explained by the existence of a land and a water hemisphere, it is purely accidental. Also, the suggestion of a triangular shape for the oceans and continents is too vague to have any meaning.

In regard to the question as to why there should be a land hemisphere and a water hemisphere, Mr. Reid says that the answer given by Herschel, about 60 years ago, is the true answer, namely, that the center of mass of the earth and its center of figure do not coincide.

In discussion of this view, Mr. Reid examines the views of such authorities as Hayford, George Darwin, Osmond Fisher, Dana Faye, Pratt, Lord Kelvin, Le Conte and Chamberlin. He concludes that there is to be found in common in their views or in the data which they use, the basis for the conclusion that the existence of a water hemisphere and a land hemisphere is due to the non-coincidence of the center of mass and the center of figure of the earth; that this is due to a difference of density in the two hemispheres, probably confined to a hundred miles or so of the surface; and that this, in turn, is due, not to unequal contraction but to a difference in the composition of the rock in the two areas.

Legendary Islands of the North Atlantic

The Mystery of the Islands of Atlantis and Brasil and Their Influence upon Columbus

By Albert A. Hopkins
Fellow of the American Geographical Society

"ATLANTIS" or "Atlantica" was described by Plato as lying just beyond the "Pillars of Hercules" (Straits of Gibralter). This legendary island, or fragment of continent which sank into the ocean, is inextricably wound up with folk-lore and the whole subject presents a very fascinating side of mythical geography. The present article without endorsing any particular set of views attempts to show certain interesting side lights on this and other mythical islands of the North Atlantic.

After the Renaissance with its renewal of interest in Platonic studies many attempts were made to rationalize the myth of Atlantis and even as late as the 17th and 18th centuries the credibility of the whole legend was seriously debated and sometimes admitted even by such men as Montaigne, Buffon and Voltaire.

A most valuable paper on this subject appeared in the little known Proceedings of the Royal Irish Academy, Vol. XXX, Section C, No. 8, written by T. J. Westropp, M.A.,[1] which contains matter of such general interest, for instance, the suggestion that Columbus was affected by these mystic isles and the repeated errors which survived until the middle of the last century, that the writer has condensed this long and scholarly paper, with its minute references, to a few thousand words. These islands are also called "*les iles fontastiques.*"

THE IRISH SEA-BELIEFS

The early inhabitants of Ireland, keenly intelligent, poetical, and with an unusual appreciation for natural beauty, stood on the western coasts face to face with phenomena of mystery and might. It is not wonderful that the great strength roaring beneath their cliff-forts and on the sandhills of their settlements deeply impressed them. Older races had bowed in awe before tamer seas; the Egyptian had feared the "great green one"; the Hebrew had seen God's path in those great waters, and had heard their hymns of praise or cries of deep anguish, when trouble was on the sea and it uttered its voice and raised its hands on high; the early Greeks had evolved from its waves and whirlpools the forms of the Sirens, Charybdis, and Scylla, with her barking waves; the tutor of Nero foretold the loosening of its bonds and the discovery of an unknown continent; while even in the deserts, far from its shores, the Arabian prophet pictured "black night on the deep, which wave on wave doth cover, cloud upon wave, gloom upon gloom." Much more so the Irish, on the outskirts of the known world, felt the wonder that we cannot shelter ourselves from, even by knowledge of natural laws; and their scholars were not unacquainted with what the Scriptures and the classics had to tell.

The coast-dwellers saw the mirage or the cloud-bank brooding on the water; to them it was a floating island,[2] possibly to be disenchanted. They saw the foam spring high out to sea, and strange reflections below the waves; it was a magic land that lay there, and the gold-roofed towers and domes glinted deep under the waters;[3] nay, it rose over the waters once in seven years, as men could attest. The ships of the Danaan and Sidh (demons and gods) sailed visible to all, reality and no mirage to the older tribes. The current suddenly foamed in a long tideway, or twisted and writhed; and to the onlookers it was clear that some vast monster swam or turned beneath it; while those lost at sea or in the surf, trying to land, were devoured (thought the survivors) by monsters. The Irish, of course, had no monopoly of such views. Even at the end of the sixteenth century Hakluyt contradicted those who said that the currents "bee swallowed by and cast up againe by the breathing of Demogorgon." The Irish went farther; they regarded the waves as sentient prophetic beings, for, in oldest Irish writers, "the great waves of

LEGENDARY ISLANDS IN THE VICINITY OF IRELAND

Erin"—Rudhraigh, Cliodhna, and Tuath—raised their deep voices to foretell disaster and crime, and the wave of Malbay mourned for the death of Keane of Ross, so late in the reign of George II.

In the center of all this weird mystery the pagan Irish placed their heaven, the "Land of Youth," the "Land of the Living," with so firm a belief that, even when they adopted a faith in whose paradise "there was no more sea," they brought their belief along with them.[4] Devout Christian writers rendered "Tir Tairngiri" as the "Land of Promise" and the "Kingdom of Heaven" in notes on the Epistles to the

[1] A book entitled "Legendary Islands of the Atlantic," by William H. Babcock will be published shortly by the American Geographical Society as a monograph in their Research Series. It will contain interesting maps and will be a scholarly contribution to an interesting subject. See also "The Island of the Seven Cities" by the same author. *Geog. Review*, Feb., 1919.

[2] So also on the opposite shore of the Old World the Chinese had legends of "Isles of the Blessed," 700 miles eastward in the Yellow Sea; places of everlasting spring, gladness and beauty. Their secret was revealed to the Emperor Tshe Huan Ti about B.C. 219. Youths went out to find the Isle, and saw it in roseate light on the horizon, but storms drove them away. Similar stories are told in Japan of the happy isle of Oraison, far out to sea.—Nansen, "In Northern Mists."

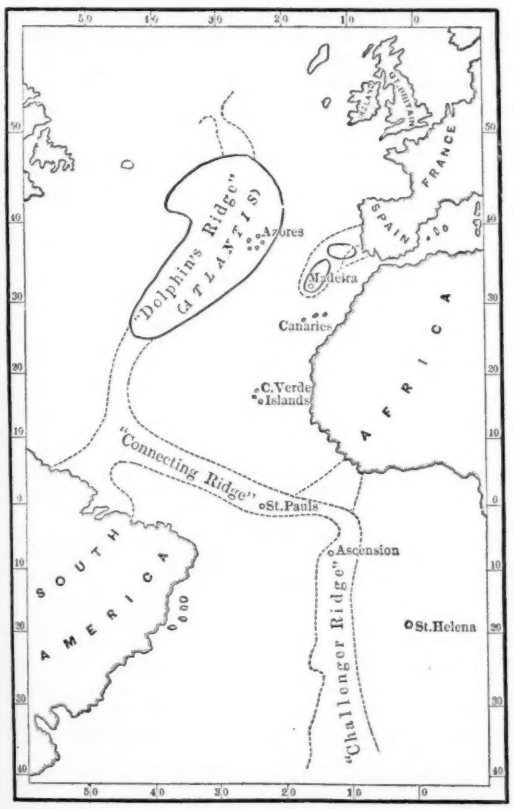
[3] "Voyages," Vol. II, p. 9.

[4] Those who held that Eden lay eastward were met (both by those who held that the earth was spherical and those who held it was flat) by the argument that Asia reached around to opposite Europe, so that the farthest east was near the west shores of Ireland.

Corinthians and the Hebrews; the blending was complete and lasting; "Magh Mell of many flowers" was the "Land of Truth," the "Land of the Promise of the Blessed," "whose truth was sung without falsehood." This, however, was equally the "Land of Fair Women," fitter for Islam than for "the Faith"; to this Isle, Connla, King Conn's son, was lured by the woman of the fairy mound. The island was not alone in the deep; "thrice fifty isles" as large as, or "twice and thrice" larger than, Erin, "were counted"; many of these figure in the Voyages of Brendan and elsewhere. The classics were brought into unison with this belief, as the Psalms had been; and we hear of the Hesperides to the west of Aran, "where the sun goes to his couch." The kindred races in Britain doubtless contributed their quota.

EARLY SEA-TALES

The early Gael loved sea-tales. How many of these were lost in the wreck of Irish literature we may never know; some may even yet be recovered, but no less than five have reached



MAP OF ATLANTIS WITH ITS ISLANDS AND CONNECTING RIDGES AS SHOWN BY DEEP SEA SOUNDINGS. FROM DONNELLY'S "ATLANTIS"

us, so we can form a good idea of the Irish belief about the outer sea. Plato's description of Atlantis is closely similar and may have become known through some Greek-reading cleric. The same seems true of Lucian's "True History." The affinities to the sagas of Ulysses, Æneas, and Sindbad of the sea are striking. The legends very probably date from the ninth century to the end of the eleventh, the earliest manuscript of "Maelduin" being just before 1100, while one of "Brendan" is alleged to be of the ninth century. St. Brendan's *Navigatio* had widespread influence on Italian thought, and are among the ancestors of the great Florentine epic. The lesser stories had little influence; but how far the *Navigatio* of Brendan reacted on Dante and the fifteenth century explorers can hardly be estimated.

Space will not permit of including a résumé of all the Irish root sea-tales, so we will pass on to the greatest sea-tale of Brendan,[5] which is called the "*Navigatio*." It exists in various stages and is possibly a ninth-century sermon elaborated up to its present form by the eleventh century. It was known in some form to the Arabian geographers in Spain about 1150. It spread beyond Ireland among the Normans, being translated for King Henry Beauclerc and his wife; and the Anglo-Norman Conquest spread it more and more. It passed to the Portuguese, and probably stimulated the designs of Prince Henry the Navigator, and a little later those of Columbus. It was a source of Dante's great poem. What truth lies behind it is difficult to guess. Matter-of-fact writers have treated it as a genuine log-book; but poets have more truly seen in it a revelation of great symbolic beauty. It is more than probable that St. Brendan (like SS. Columba, Colman, and Flannan) was actually a daring voyager; and that in some lost "Life," his actual visits to various islands were told. We are less concerned with the actual facts than with the stories that so impressed the world. Columbus was in touch not only with the Portuguese, but with Bristol, the merchants of which sent seven expeditions to search for "Brasil" before the fifteenth century ended. He also had at least one Irish sailor with him on the great voyage of 1492; from any or all of these he may have heard the Brendan legends.

THE MOST FAMOUS OF THE PHANTOM ISLANDS

"Brasil" or "Brazil" takes a prominent place in the early maps of Italy, Spain, France, and even England and Germany. Its name is obscure; some say it is from the Irish "Bres," noble, or, as Nansen says, "fortunate." It was clearly brought about in prehistoric times by mirage and fog-bank. The setting sun and the place of the dead helped its religious significance; it became the "Isle of the Living," the "Isle of Truth," the "Isle of Joy," the "Isle of Fair Women," the "Isle of Apples," "an Eden, away, far away." Christianity, trustee to dead Paganism, made it the "Land of Promise." Then the belief materialized before commerce, and it became (as Sir David Wilson writes[6]) "an imaginary island of Brasil that flitted about the maps of the fourteenth and fifteenth centuries with ever-varying site and proportion, till it vanished. It was not a reef or a shoal, but a mist or mirage 'sprung from the sea without root'; but it held its place on the charts from 1320 to 1865, and was said to have been seen at close quarters in 1791."

COLUMBUS AND THE MYTHIC ISLANDS

This is no place for any elaborate study of the most interesting question relating to the mythic islands, namely, how far the belief in them affected the discovery of Columbus. A few notes must suffice. It will be remembered that Christopher Columbus based his great enterprise on three errors—the extension of Asia so far eastward as to reach within a comparatively short distance from the west of Europe; the inaccurately small circumference of the world; and the existence of large islands in mid-ocean. The maps of two centuries and the traditions known to him bore out the last item. The Spaniards believed so firmly in the Isle of the Seven Cities that they actually inserted a clause in the Treaty of Evora with Portugal, reserving "the islands which had not been found," and the people of the Canaries also petitioned to be allowed to annex it. Columbus, as his son Ferdinand records, knew of Seneca's future continent and of Aristotle's *Antilia*. This almost certainly implies knowledge of the Atlantis legend. He gathered all he could learn of these and of St. Borondon's Isle, and the Seven Cities. He had heard of Antonio Leone (or Leme) reaching an island 100 leagues west from Madeira, of two floating islands, more to the south-west, mentioned by Juventius Fortunatus, and of a Madeiran asking for a caravel in which to seek for Antilla. Peter Velasques, a pilot, told Columbus at La Rabida how, in the time

[5] The literature on this subject is large. Consult Rev. S. Baring Gould, "Curious Myths of the Middle Ages."

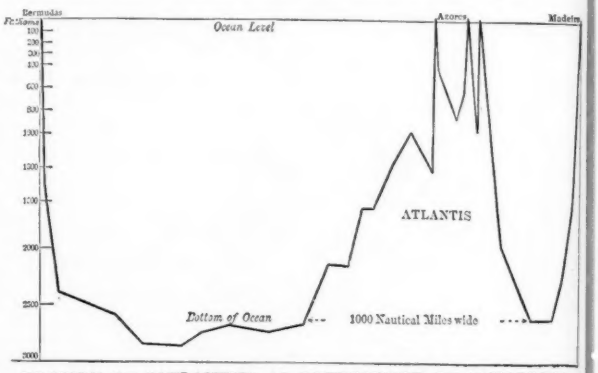
[6] "The Lost Atlantis," 1892.

of Prince Henry, his Master (born 1394, died 1460), James de Fine, going from Fayal to Cape Clear, in Ireland, about 1450, got under shelter of an unknown isle to the west of Ireland. Peter Velasques, of Galicia, confirmed this of his own knowledge, and Columbus had a letter of Vincent Dea, a Portuguese, telling how he had seen an island beyond Madeira. The great explorer went northward, heard what the Bristol merchants (indefatigable seekers for Brasil) had to tell, and in February, 1477, sailed 100 leagues beyond Thile (Ireland). There, if the passage be not an interpolation, he may well have seen manuscripts such as exist, dated fifty to seventy years before his visit, telling, in matter-of-fact words, of Greenland, Helluland, Markland, and Vinland (the last "stretching toward Africa"), with wide channels between, and manuals are often more convincing than folios. He was in touch with Galway, the center of Irish lore of Hy Brasil, for he included among his sailors in 1492 William Irez, of Galway, in Ireland. He cites religious legends for accounts of the wonderful birds and plants of the ocean islands. He fully expected to meet such islands on his way to Cipango, Cathay, and the Indies; what he did not expect was to be walled off from Asia by a vast continent. The belief in the islands must have been of the first importance to encourage him and his men on their daring voyage when they burst into the silent sea.

ATLANTIS AND OTHER LOST LANDS

Though it has not been demonstrated that Plato's[1] descriptions of Atlantis were known to the Irish, the probability is considerable. Seneca's works were actually in the Library of the great Hiberno-Italian school of Bobbio, while St. Gall had another famous early library to which scholars (and perhaps monastic redactors of the Brendan Saga) would most likely have resorted. This is no place to go deeply into the question as to whether Plato actually heard a genuine legend of Egyptian priests from the time of Solon, and if so how an alleged historic event of B.C. 9600 could have been handed down even to the Egyptians of the early dynasties 5,000 years later. The point which concerns us is the unmistakable likeness of the mythical Atlantis to the islands seen by the Irish writings concerning Bran, Maelduin, and Brendan. As in "Bran," where the sea-god Mananann is father of Mongan by an Irish princess, so, in Atlantis, his equivalent, Poseidon, has ten sons by mortal mothers. Atlantis has a marvellous fort with rings of three fosses and two walls of bronze, tin, and *aurichalchon* or red copper; so, in the legends of Maelduin and Hui Corra, is the ring-fort with brazen rampart, palisade, and bridge over a wet fosse. Atlantis was walled all round, so are the Irish legendary isles. In both we hear of wonderful temples and altars, founts of hot and cold water, well-planted groves and a wonderful race course; the parallel is close indeed, whatever degree of connexion there may be between them. Atlantis is said to have lain outside the Straits of Gibraltar, to have been as large as Asia (Minor) and Lybia combined, and, after overrunning all the Mediterranean shores to Tyrrhenia and Egypt, its armies were checked by Athens; eventually it sank in a day and a night during an earthquake, and was entirely submerged by the sea, leaving dangerous shoals. The resemblances between Lucian's "True History" and the Irish tales are most striking.

The Atlantis legend reached the Arabian geographers along with the Irish and Norse tales. The Arabs were believed to have crossed the Atlantic; and the Observatory of Sagres, under the influence of Prince Henry the Navigator, collected all records of voyages, with the result that Madeira was rediscovered (or discovered if the alleged Bristol settler be mythic), and the voyages commenced which at last doubled the Cape of Good Hope. The nearest neighbors of the early Irish were not without similar beliefs. The Britons believed in the elusive Isle of Avalon. The Welsh, too, had their great lost land sunk by a drunken, careless prince. There was also the lost land of Lyoness, or Lennoys, of which the Scilly Isles are said to be the last remnants. Florence of Worcester (died 1118) tells of its flourishing condition and how it sank, like Atlantis, beneath the waves. It, like Avalon, was never placed on the early maps, and there is no evidence that it affected either the Irish or Iberian beliefs, though it secured a place in English literature through Tennyson and Swinburne. Scotland, too, had her "Flaith Inis," which was surrounded by clouds and tempests, with an island, "Caerecennfinn," between Scotland and Ireland, where the Irish of Ulster placed their "Tir Hudi." The Bretons had their submerged city of Is; the French and Portuguese told of the mythic Isles of Maida, Asmaida, or Asmanda and Isle of Verte, Ilha Verde, suggesting the Inis Glas of other legends. The Spaniards had their tale of Antilia and the Isle of the Seven Cities of the Gothic kings and bishops who fled from the Moors to them in 714, while Ireland, England, France, Portugal, and Spain agreed in believing that outside human trade, rarely within the limits of sight, lay Brasil and St. Brendan's Isle, the Fortunate Islands, the Isle of Birds, and the Isle of Sheep. The reader who is interested in Atlantis and who wishes to carry on further reading can consult the best authority, Pierre Termier. "Atlantis" in the Annual Report of the Smithsonian Institution for 1915, pp. 219-234. This translation is more accessible than the original paper



PROFILE OF "ATLANTIS" AS DETERMINED BY "CHALLENGER" AND "DOLPHIN" SOUNDINGS. FROM DONNELLY'S "ATLANTIS"

which appeared in the *Bull. de l'Inst. Océanogr.* No. 256, Monaco, 1913. At the request of the American Geographical Society this brilliant paper was reviewed in their journal, the *Geographical Review*, for January, 1917, by Dr. Rudolph Schuller, formerly of Para, and Prof. Charles Schuchert of Yale.

In the early eighties Ignatius Donnelly, a prominent thinker of the time, presented what will probably remain the best brief for the existence of this remnant of a continent called "Atlantis," in a book which is a marvel of logic, called "Atlantis: The Antediluvian World." This work set out to demonstrate several distinct and novel propositions. These are:

1. That there once existed in the Atlantic Ocean, opposite the mouth of the Mediterranean Sea, a large island, which was the remnant of an Atlantic continent, and known to the ancient world as Atlantis.

2. That the description of this island given by Plato is not, as has been long supposed, fable, but veritable history.

3. That Atlantis was the region where man first rose from a state of barbarism to civilization.

4. That it became, in the course of ages, a populous and mighty nation, from whose overflowings the shores of the Gulf of Mexico, the Mississippi River, the Amazon, the Pacific coast of South America, the Mediterranean, the west coast of Europe and Africa, the Baltic, the Black Sea, and the Caspian were populated by civilized nations.

5. That it was the true antediluvian world; the Garden of

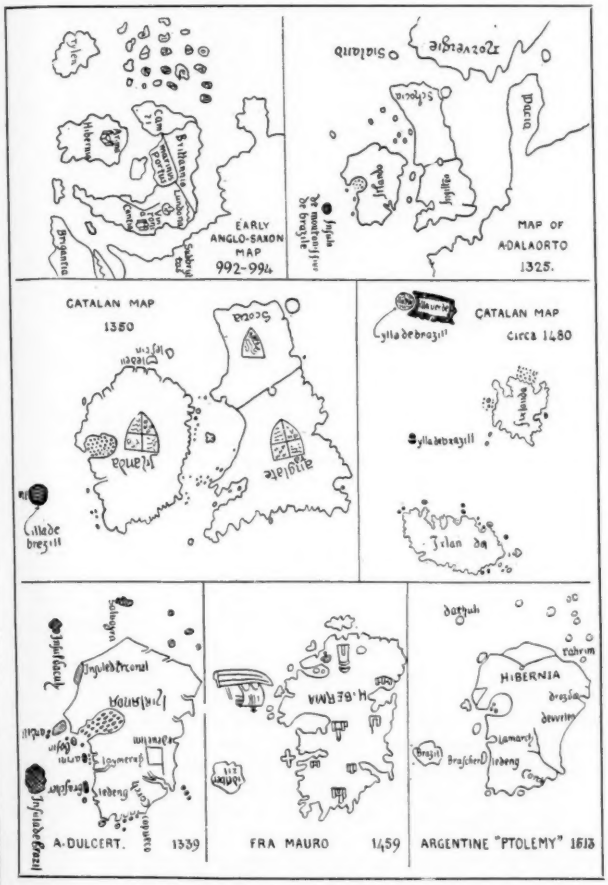
[1]Plato, "Timaeus" VI.; and "Critias III. VIII. XV. See also Dr. Robert F. Sharff's paper, "Proceedings of the Royal Irish Academy, Vol. XXIV. Section B., Part III.

Eden; the Gardens of the Hesperides; the Elysian Fields; the Gardens of Alcinous; the Mesomphalos; the Olympos; the Asgard of the traditions of the ancient nations; representing a universal memory of a great land, where early mankind dwelt for ages in peace and happiness.

6. That the gods and goddesses of the ancient Greeks, the Phoenicians, the Hindoos, and the Scandinavians were simply the kings, queens, and heroes of Atlantis; and the acts attributed to them in mythology are a confused recollection of real historical events.

7. That the mythology of Egypt and Peru represented the original religion of Atlantis, which was sun-worship.

8. That the oldest colony formed by the Atlanteans was



EARLY MAPS SHOWING "BRASIL" ISLAND

The maps are properly ornamentated although many of the letterings and symbols are inverted. Many place names have also been omitted in the interests of clarity.

probably in Egypt, whose civilization was a reproduction of that of the Atlantic island.

9. That the implements of the "Bronze Age" of Europe were derived from Atlantis. The Atlanteans were also the first manufacturers of iron.

10. That the Phoenician alphabet, parent of all the European alphabets, was derived from an Atlantis alphabet, which was also conveyed from Atlantis to the Mayas of Central America.

11. That Atlantis was the original seat of the Aryan or Indo-European family of nations, as well as the Semitic peoples, and possibly also of the Turanian races.

12. That Atlantis perished in a terrible convulsion of nature, in which the whole island sunk into the ocean, with nearly all its inhabitants.

13. That a few persons escaped in ships and on rafts, and carried to the nations east and west the tidings of the appalling catastrophe, which has survived to our own time in the Flood and Deluge legends of the different nations of the old and new worlds.

THE MYTHICAL ISLANDS IN EARLY MAPS

Interest in the islands of the Atlantic hardly existed before the twelfth century among the map-makers. The "Life of St. Brendan" had been spreading over the Continent for over a century before it began to affect the maps. Apart from his works there is no certain trace in the other maps of the imaginary isles till Dulcert in 1325 to 1339. These charts founded on experience and, as their name implied, showing the route from port to port, avoided the conventional, and strove to draw information from every source. The island corresponding to Brasil is also found in the Venetian map of 1367 and the far superior Catalan map of 1373, which marks a large circular island "Insula Berzil," in the same place, west from the Shannon, as also St. Brendan's Isle and Mam to the south of Brasil. It will be remembered that the compass was apparently known in the thirteenth century to Roger Bacon, and later to Dante's tutor, Brunetto Latini; but the latter says that sailors would not have it on board, regarding it as "an infernal spirit." It only became popular about 1360, so that its use, the making of the early maps, and the "appearance" of Brasil, all seem to be contemporaneous. The I. de Brazil is shown among the Azores, and a nameless isle, the mythic "Brazil," to the west of Ireland in the Venetian map of Andrea Bianco in 1436. One of the finest maps before Columbus, that of Frau Mauro, in 1459, identified Brasil with the Fortunate Islands. Mauro was known as the "*Cosmographus incomparabilis*"; he was a Venetian friar, and a medal was struck in his honor. To the fifteenth century belongs a Catalan compass chart; it marks "Ylle de brazill" a double island and (twice as far from Irlanda as it) another Brazill to the west of it, Ille Verde, and still further to the north "Fixland," apparently Iceland. In the very year when Columbus first reached the islands of America, Martin Behaim (or Bohemus) of Nürnburg made his famous globe. It shows Brasil and St. Brendan's Isle, the latter half-way between Ireland and Japan, in 1492.

If interest in geography was getting so keen and bearing fruit in the Portuguese expeditions down the coast of Africa, and the Spanish ones to the West Indies, it might be expected that it grew keener than ever after the great turning-point in history of that year, when "Columbus gave a New World to Castile and Leon." Two names passed from mythic and half-mythic islands; "Brazil" and "Antilia" attached themselves to actual countries; but though Antilia passed from the map of the Old World, Brasil still held its own off the Irish coast, though its name had been transferred to the land of the giant river and forests, greater and more beautiful than bard or monk had ever fancied.

England, having so narrowly lost her chance of being patron to Columbus, was now taking her place among the world-explorers. In August, 1497, the minister of the Duke of Milan wrote to his master from England to say that Cabot had found two large and fertile islands, San Juan and Prima Vista, and had found the "Seven Cities," 400 leagues from England. Eleven months later the Spanish Ambassador in London wrote to Ferdinand and Isabella, telling of Cabot's discoveries and second expedition, and telling how "the men of Bristol have, for the last seven years" (since 1492), "sent every year, two, three, or four caravels to search for the Isle of Brasil and the Seven Cities." Next year, 1499, the real Brazil was discovered.

The increasing traffic with America in the sixteenth century might have been supposed to have swept all the mythic tales into the "Never-Never Land," whence they had come; but this was not the case; and we must see how for some three centuries the islands held their own, while, perhaps, the earliest and latest of the group, Brasil and Buss, were found on maps till past the middle of the nineteenth century. In 1598 and 1599, Hakluyt gives Iceland,[8] with Frisland, half way between

[8] "Voyages," 1599, Vol. II., p. 33.

it and Estotiland. Not content with this, he collects a circumstantial report of the finding of Buss, the latest mythic island of the North Atlantic, and which (with Brasil, the earliest to find place on the maps) held its own down to very recent times. The most interesting section of the map-history of Brasil and its sister isles ends with the sixteenth century. A few instances are given in the original paper to show the continuity of the belief. Estotiland, St. Brandon's Isle, and Antilla, do not appear in any map after 1700, as far as Mr. Westropp knows; Brasil, Buss and Maida survived. Brasil is in Jeffrey's American Atlas in the year 1776 in longitude 17°35′ west, and lying west from Cape Clear. St. Brendan's Isle is also given. Buss was only eliminated in 1850. Brasil was finally removed from the charts so late as 1865. John Purdy's general chart of the Atlantic (corrected in 1830) says that the Brasil Rock was high and was fixed at 51°30′ west. In a chart of currents in A. Findlay's edition of "Purdy," and in the "Memoir, Description, and Explanation of the North Atlantic Ocean" we read "Brasil Rock, lat. 51°10′, long. 16°" M. Bellin in 1742 states that this rock is "marked in lat. 51°10′, long. 19°30′ Paris." Its existence has been doubted by Messrs. Verdun and Border. "It was, however, seen in the year 1791 by the company and master of an English merchant ship, the commander of which favoured the world with a description of it, stating that it is really a high rock, or islet, and by which he passed so near that he could have 'cast a biscuit on shore.' We suspect that if it exists it is more to the westward." Findlay's doubts increased, and he eliminated Brasil finally in 1865, after it had held its place for over 550 years on the maps. Local histories assert that the Channel Isles were connected with France up to 709, and that when St. Lo visited Jersey on inspection in 565 he could cross into it by a plank.

CONCLUSIONS AS TO THE LEGENDARY ISLANDS

Mr. Westropp sums up his conclusions, leaving to scientific men the questions of subsidence and the formation of the ocean-beds, which some have put back to the dateless Miocene:

1. The outer isles, Brasil, Brendan's and Ailbe's, are purely mythical, or, at best, based on mirage and fog-bank. This may be modified, should it be proved that the Porcupine Bank (which so closely corresponds in position with Brasil) has been above water even in an early human period.

2. The traditional islands along the coast, which are represented by actual reefs, were very probably actual islands down to a late period. The case of Mutton Island, split into three parts between 799 and 803, shows that the deep hollows now found between the fragments belong to merely 1100 years of denudation.

3. Of folk-lore, the power of fire to disenchant and fix firmly any phantom island is a cardinal article of belief; so is the appearance of these lands at intervals of seven years.

4. Some islands, though possibly none in these coasts, may have been upheaved and sunk by some volcanic outburst. Very possibly some such event originated the tradition of the vast continent sunk in the waves of which Plato told.

It is probable that red dye woods used in the Middle Ages were connected with Brasil, the mythical and that the familiar existence of "Brasil" as a geographical name led to its bestowal upon the vast region of South America, which was found to supply dye-woods kindred to those which the name denoted.

OCEANIC CURRENTS AND DENSITY OF WATER

STUDIES by M. J. Thoulet concerning ocean currents and density recently formed the subject of a paper read by the Prince of Monaco before the French Academy of Sciences at the session held April 4, 1921. An abstract of this taken from *Le Génie Civil* (Paris) for April 16, 1921, is given below:

Marine currents are the result of an infinite number of causes which vary greatly with regard to their importance. Chief among these are the wind, the rotation of the earth and the two antagonistic effects of heat, which on the one hand causes the water to expand and thus make it lighter, while on the other hand it produces evaporation, thus increasing the concentration and making it heavier.

The latter two influences are characterized by a single variable, the density *in situ*, *i.e.*, the weight of a cubic decimeter of water under given conditions of temperature, salinity, and even of *pressure* when the specimen examined is taken from deep waters—or when it exerted an influence in nature such as forms the subject of the following experiments:

Since the density *in situ* gives the total amount of the algebraic addition, it is important to guard against any separation of the two factors concerned, temperature and salinity. Regarded from the point of view of its density *in situ* the sample is, so to say, *living*, while its normal density at zero characterizes its *dead* state, *i.e.*, when contained in a bottle in order to be compared with other bottled samples. The object to be attained, therefore, is the prompt and precise estimation of the density *in situ*, by an easily applied process, of samples procured simultaneously at various points on or below the surface, in the same current, making use of as small quantities as possible when the sample is taken from deep water.

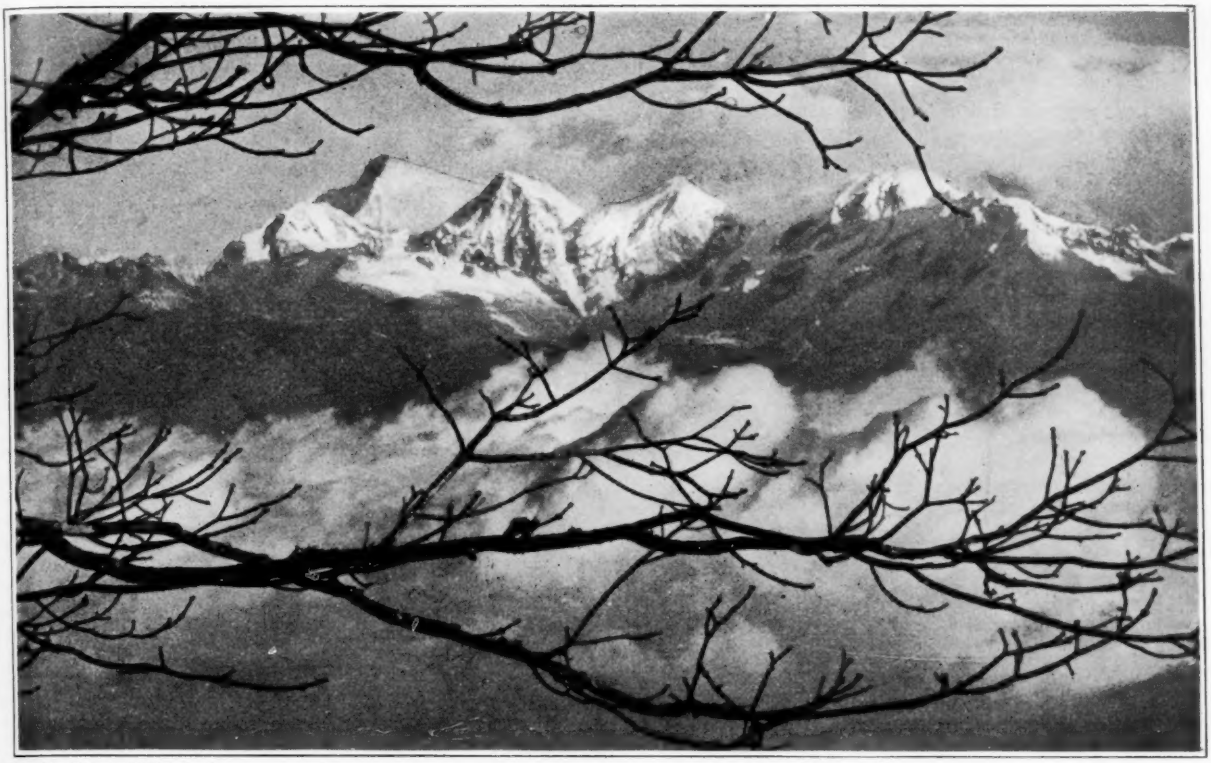
These requirements are conveniently met by the use of an indirect method of measurement. This consists in finding at first, at the surrounding temperature, the index of refraction of the sample by means of a suitable refractometer (the best one for this purpose is the Abbe instrument, especially the model called the *plunger*), and then making use of this datum by means of special graphic tables, to find the value of the density *in situ*, and then, if it be judged necessary, the values of the normal density, the degree of salinity and the amount of chlorine contained.

The entire operation takes only a few minutes and furnishes the density sought with an approximation of only 1 or 2 units of the fourth decimal. The address concluded by a statement of the data found in this manner.

CHEMISTRY OF THE EARTH'S CRUST

IN an article published in the *Journal* of the Franklin Institute (December, 1920, pp. 757-815) H. S. Washington gives tables showing the distribution of igneous and sedimentary rocks in the crust of the earth, the latest estimates of the composition of the crust, and the relative amounts of the elements. The elements are referred to two main groups of the periodic table: (1) The petrogenic elements, characteristic of and most abundant in the igneous rocks, are of low atomic weight and occur normally as silicates, oxides, chlorides, and fluorides. (2) The metallogenic elements, rare or absent in igneous rocks, but occurring as ores of high atomic weight, and forming "native" metals, sulphides, arsenides, etc., but not primarily silicates. In igneous rocks and minerals the elements show a correlation, in that some of them are prone to occur with others. Moreover, the igneous rocks themselves occur in regions where they are chemically related—called "comagmatic regions" in America and "petrographic provinces" in England. The calculation of rock densities from their chemical composition is discussed, and the results are shown to confirm the theory of isostasy.

Earth's Interior.—Knowledge regarding the earth's interior is summarized. It is essentially a rigid solid; hot, with the temperature increasing toward the center at a variable but unknown rate. Its mean density is about twice that of the crust. It acts as a magnet, and since the surface rocks are not very magnetic, this character may be attributed to its interior materials. The center of the earth from about half the radius is composed of different materials, is of high density, and does not transmit torsional vibrations. The density cannot be accounted for by compression. The suggestion is made that below the silicate crust is a zone essentially of nickel-iron, and beneath this a central core of metallogenic elements. This agrees with the magnetism and density of the earth, and with Abbott's views as to the distribution of elements in the sun.—From *Science Abstracts*.



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SUNRISE ON THE HIMALAYAS, "THE ROOF OF THE WORLD"

The World's Greatest Adventure

The Ascent of Mt. Everest as a Test for Human Endurance

By H. Snowden Sinclair, A.M.

THERE are few worlds left to the explorer to conquer. The poles have lost their mystery; there is little sport in tracing the head waters of a mighty or unknown river; but there remains one more feat to be accomplished—the climbing of Mount Everest, "the dome of the world." As we write, somewhere in the tangled maze of the southern Himalayan Mountains three parties of British engineers are working their way through unexplored gorges and passes toward the base of Mount Everest. They are blazing the way for the expedition that will later this summer attempt to scale the granite walls of Everest and conquer the highest mountain peak on the globe.

The first party to leave Darjeeling was commanded by Major Morshead, which proceeded up the Teesta Valley and over what is known as the Kangrila route. The other two units, commanded by Col. Bury, intend to meet the Morshead party at Khamba Jong, and then the combined expedition will strike westward toward the village of Tingri Jong, which is about thirty miles north of the Everest group. A permanent base will be selected near that village, and from it will start the party which will try to reach the summit of the dominating peak of the range. Before the actual work of scaling the stupendous slopes of Everest can begin, however, engineers must carefully survey all approaches to the mountain and try to find the most practicable route to the top. This reconnaissance work is the chief task assigned the men now working their way into the heart of the mountains.

The world's highest ground—or snow—rises 29,141 feet above sea level, and dominates a vast array of mountains which form the national boundary between Nepaul and Tibet. The great virgin summit is wreathed in eternal snow. Its supporting bastions are sheathed in ice and bulwarked by huge precipices, where monster avalanches thunder and roar, while fierce storms wage unceasing war on the earth's uttermost stronghold. At first sight it seems like a gamble against Fate, with human life as the stake, for man to attempt the conquest. Yet these grim terrors and the added difficulties of mere existence on the real roof of the world but increase the keenness to these sporting Britons who hope to plant their flag on the summit. At the outset the odds will be on the side of the mountain; but pluck and skill will prevail. Mr. George D. Abraham, an accomplished writer on Alpine subjects, writing in *The Illustrated London News*, fixes five years as the shortest possible time for final success, but the explorers themselves hope their efforts will be crowned by success in 1922.

FORMER ATTEMPTS

Up to the present, entry into the Forbidden Land has been impossible for political reasons: but the Indian Government has made arrangements to permit the passage of the expedition to the base of the mountain. "Jomo Kang Kar," or "Our Lady of the Snows," is an object of reverence and worship by the natives, and they may resent the intrusion of white men on their lofty shrine. The expedition is organized and financed by the Alpine Club and the Royal Geographical Society, and Sir Francis Younghusband, president of the latter society, has been very much interested in the subject since his remarkable expedition to Tibet in 1904.

There have been several former expeditions to other parts of the Himalayas, and most of them have had trouble with the natives. As long ago as the years 1854-1858 some very remarkable climbs were made by the two brothers, Adolf and Robert Schlagentweib, who reached a height of 22,259 feet on the great peak of Kamet (25,443 feet). After this Adolf crossed the Karakoram Pass, and was murdered at Kashgar. Then, in 1895, the attack on Nanga Parbat by A. F. Mummery came to a mysterious end. At the base of this magnificent icy obelisk the climbers divided. The leader of the party, with two natives, was to cross a short pass from the west to the north side of the mountain, and meet the main part of the expedition which had traveled round by a longer route. After bidding farewell to his friends, Mummery and his companions were never seen again. No trace was ever found, says Mr. Abraham. Those who knew the skill of the greatest of British mountaineers cannot believe that an avalanche caused disaster. Yet these monster mountain falls will prove one of the greatest dangers to the forthcoming expedition. Everything is on an immense scale in the Himalaya. Crevasses are thousands of feet deep. A simple snow-slide in Scotland, or an Alpine avalanche, becomes on the roof of the world a tremendous cataclysm, which shakes the greatest mountain to its very base, and which may be heard, or even felt, fifty miles away. A more insidious risk lies in the smaller avalanche started by human agency. One attempt on Kangchenjunga (28,150 feet), the third highest known peak, ended in tragedy. From a camp 20,343 feet high a section of the party decided to descend on account of a difference of opinion. Three amateurs and three coolies were crossing a snow-covered slope when two coolies on the middle of the rope slipped, peeling the loose snow off with them. In an instant all were carried off their feet and flung down the icy slope, a veritable human avalanche. Two Continental climbers were the only survivors. The four bodies were not recovered until three days later. They were buried under twelve feet of solid snow.

MOUNT EVEREST WHICH TOWERS 29,140 FEET ABOVE SEA LEVEL
This is one of the few genuine photographs of this famous mount.

The expedition to Mount Everest will find that serious rock-climbing is encountered before the valleys are left behind, but they will be well equipped with skill and knowledge to meet all contingencies, as far as is humanly possible. The real test will come when the 20,000-foot level is gained. Even before this, that grim enemy, mountain sickness, will have sorted out the weaklings, and, gradually, only the soundest will remain at the loftier camps. In this connection we quote as follows from *The Alpine Journal* for March, 1921, the writer being Prof. J. N. Collie, a well-qualified expert:

PHYSIOLOGICAL DIFFICULTIES

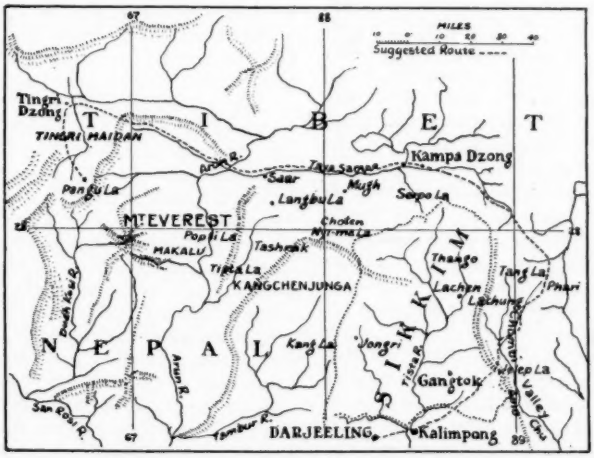
"It is the physiological difficulties, however, that play far the largest prohibitive part in high ascents. We yet have much to learn about them. The lack of oxygen and the effect of intense cold are the two chief difficulties to be conquered. The lack of oxygen at high altitudes is of course due to the rarefied air. During respiration the body gets its oxygen through the ultimate ramifications of the lungs—the alveoli; and it is through them that the blood becomes oxygenated before it returns to the heart, ultimately to do its work of oxidation of the tissues of the body. Should there be a deficiency of oxygen the natural processes of the body are at once interfered with. If one takes an engine, and in one hour burns in it a hundredweight of coal, we get a certain amount of energy produced. But if for one hour we cut off the supply of air so that only one-third of the coal is burnt we naturally only get one-third of the energy.

"On the summit of Mt. Everest one is supplied with only one-third of the usual amount of oxygen. The question is, Can the human engine do much work with this limited supply? Fortunately the body can acclimatize itself to a considerable extent to changed conditions. For instance, people who ascend Pike's Peak, 14,109 feet, in the United States by railway suffer from faintness, sickness and blueness of the lips and cheeks, breathlessness and general lassitude. Their blood is unacclimatized to the deficiency of oxygen. Yet on the Pamirs at 15,000 feet and above, people live their lives comfortably and do hard work; they are acclimatized. The chief effort of the body to counteract the deficiency of oxygen is to increase rapidly the number of blood corpuscles. These corpuscles are the carriers of oxygen from the air to the interior of the body. Double the number of these little carriers in one drop of blood, and that drop will carry twice as much oxygen to the tissues for available energy and life.

"The number of such corpuscles in a cubic millimeter of the blood of a person at sea level is usually less than five million. The average count of a native of the Pamirs is over eight million. On the Pamirs there is only about half as much oxygen in a cubic foot of air as at sea level. People who make rapid ascents to high altitudes in balloons and airplanes are unacclimatized. Tissandier in a balloon ascent fainted at 26,500 feet, and on regaining consciousness found both his companions dead. Yet on the other hand the Duke of the Abruzzi at 24,583 feet, and Rubenson and Monrad Aas at 24,015 feet, were not only capable of living but doing work as well. They were acclimatized by living for some time at the reduced pressure. Another factor that favors the trained mountaineer is that a trained man needs much less oxygen during work than an untrained man. He is an engine working with the maximum economy.

"The effects of intense cold on the human system is to lower the vitality, and there is no doubt that the cold at altitudes above 20,000 feet, with a wind, becomes almost paralyzing. Longstaff, Meade, Rubenson, all suffered from it. Yet Henri Brocherel after three nights out, the third spent in a hole in the snow at 23,000 feet, was able and anxious to continue climbing. There is little doubt that with acclimatized climbers in first-rate training a greater height will be reached than 25,000 feet. But it only will be done under the most favorable conditions.

"Probably the greatest difficulty will be getting the camps up to the high altitudes. The record at present is that of Mr. Meade's coolies, 23,600 feet on Kamet. Given another 1,700 feet and a camp 4,000 feet from the summit of Mt. Everest could be made. If the climbers in this camp were properly warmed and properly fed a push for the summit might be made. Dr. Longstaff 'rushed' Trisul, climbing almost 6,000 feet from his camp, and several other climbers have ascended many thousand feet in one day at very high altitudes. We more or less know that the physical difficulties on the summit of Mt. Everest are not prohibitive, and there is every reason to hope that the physiological ones will also not be great enough to stop a really determined attempt made on the mountain under favorable conditions."



MAP OF THE REGION OF MT. EVEREST
The dotted line shows the route which the expedition is taking

Mr. Abraham thinks that airplanes will not be used by the expedition at the outset. In fact, it is more than doubtful whether they will be of any real use at all. Control for landing purposes is impossible in the thin upper air, and as oxygen cylinders have to be used to sustain the pressure-stricken airmen, on account of the sudden uprush, it is evident that observation, a difficult undertaking among mountains, will be unreliable.

THE PLANS OF THE EXPEDITION

Two of the members of the expedition have written interestingly of their plans in the *Geographical Journal*. Col. Howard Bury, chief of the expedition, writes as follows:

"Part of the expedition may have to live at great heights for a considerable time, and one has been experimenting with small details such as primus stoves to burn at over 20,000 feet. You cannot keep fit unless you have good and hot food. It is of the very greatest importance to have food easily digestible, which can be easily warmed up at very great heights. The expedition has been organized by Sir Francis Younghusband, and to him has been practically due the fact that it has been brought into being. His energy here and his work with the various authorities have brought the expedition into being. The main object of the expedition is the ascent of Everest. But besides that, as Prof. Norman Collie has said, there are some very important subsidiary objects to be attained. The whole country to the north of Everest is completely unknown. The maps we have are all very problematical, and where you see a range of mountains marked in the map you may find it is a valley or lake, and as we go along we shall have to map our way. The Government of India has very kindly given us the loan of two officers of the Survey of India, both accustomed to mountain survey, and with them we shall have to work and map the whole of that country to the north of Everest, as well as the Mount Everest group; this alone would furnish a full summer's work. With these officers will be assistant surveyors, and a great deal of work has to be done. The Arun Valley is probably quite wrongly mapped, and we are very doubtful as to the exact position of those ranges of mountains marked to the north of Everest. The draughtsman who compiled the map told me they were put in to fill up!

"Now, Mount Everest is becoming known, like many other places at one time unfamiliar, as the island of 'Yap' came into prominence a few months ago. I heard two ladies discussing the expedition recently, and at last one said to the other, 'And where is Mount Everest?' 'Oh, somewhere in Iceland!' Another remarked to me, 'Oh, how very interesting your going to Everest! I hope you may get to the top, and then you may bring back a piece of wood from the Ark!"

"We have a good botanist and naturalist, and there is every probability of our discovering many new flowers; but that very much depends on how far the monsoon currents penetrate up the Arun Valley. It is extraordinary on those dry plains, which look so barren in the photographs, what beautiful flowers there are—most lovely rock plants, blue poppies, primulas, and all kinds of delightful flowers. There is also the geological work. We are probably getting either an officer or assistants from the Government of India for making a geological collection. We know there are a large number of animals up there. You get Ovis Ammon, one of the largest sheep in the world; possibly an antelope, certainly a gazelle, and partridges, and there is a great field for a naturalist.

"The Government of India is kindly giving us the loan of 100 mules for the expedition. This will be of the very greatest assistance to us, and we know now we shall have no difficulties with the transport. Lord Ronaldshay, the Governor of Bengal, is extremely interested in the expedition, and we are lucky in having him there. Colonel O'Connor is political agent in Sikkim, and his duties carry him right up into Tibet. He was with Sir Francis Younghusband in the expedition of 1904.

"It is, therefore, a specially favorable time for us to make this expedition with so many friends who will be quite ready to help us. There is a very elaborate photographic equipment going out with the expedition, so that we hope to bring back many records. Unfortunately the camera cannot reproduce the extraordinary beauties of color there are in Tibet—greens, and reds, and orange, under a brilliant blue clear sky. It is a wonderful expedition, full of interest of all

kinds, and when we come back I hope we shall have a very interesting tale to tell you."

THE MOUNTAINEERING

Mr. Harold Raeburn, leader of the mountain party, writes as follows:

"Seeing that the political difficulties in connection with this expedition have been so happily overcome, we shall hope that difficulties of approach, that Prof. Norman Collie has described as very great, will also be successfully overcome owing to the careful organization of the transport, which is really the secret of getting a large party up there. There remain the mountaineering difficulties, and these will undoubtedly be extremely great. No one has ever seen the real approaches to Everest because its lower slopes have been always concealed by the shoulders and slopes of its mighty neighbors. I do not think the northern ridge will prove at all possible, because I do not think anybody can live at such enormous elevations for such a long time as would be necessary. I was privileged last year, by very kind permission of the authorities of India and Nepal, to make a reconnaissance of Kangchenjunga, and I think in studying passages and probable conditions, we can, to a large extent, depend upon analogy. Great snow mountains are great snow mountains all the world over. These two great constellations of peaks, Everest and Kangchenjunga, at no great distance apart, are separated by an enormous river valley, the Arun, but probably conditions are very much the same. I think it very unfortunate indeed that for political reasons alone we are precluded from taking the easiest route from the south. We must find some sheltered face route, and I believe that the northeast will be the most favorable for this reason, that the northwest is probably much steeper, and it has the cold aspect. Now altitude and cold are the two great things we have to struggle against. If we can get on the northeastern side we shall be much more likely to have sun early in the morning. As regards the actual mountaineering, everything will depend upon the training of the coolies, for I do not believe that Europeans can carry at these heights. Above 21,000 feet one has to have really well-trained and young, active men, and support them in every way. We may take it that this year will be reconnaissance first of all, but there is no doubt we shall try to get as high as we can, for Italians and Norwegians are ahead of us at present in altitude records. We intend anyway to do our very utmost to explore this great mountain so far as may be possible, and to justify Sir Francis Younghusband's keen interest and able generalship which has rendered it possible."

THE HIGH CLIMBING

Mr. (or rather Captain) George Finch, whom we saw repairing his boots in the June issue of the SCIENTIFIC AMERICAN MONTHLY, writes as follows:

"Those of us who have been selected by Sir Francis Younghusband to make, under the leadership of Mr. Raeburn, the attempt to climb the highest mountain in the world, do not conceal from ourselves the fact that we may expect to face great difficulties and dangers. I have heard a comparison drawn between this expedition and Polar expeditions. Such a comparison I have not found easy to draw. The Polar expedition is a long drawn-out struggle of several months. On this expedition remarkable difficulties are not likely to be met with below 20,000 feet. The ascent, however, of the remaining 9,000 feet to the summit of Everest will, if at all, be carried out in ten days or even less, and it seems to me those days will be replete with concentrated effort and strain such as no other expedition has ever demanded. I do not fear our inability to piece out an ultimate route up the mountain. By possible route I mean a route which is not only climbable, but where we are more or less safe from the danger of snow, ice or rocks falling upon us. The risk of our falling ourselves I hope may be eliminated. The question is whether the conditions will allow us to follow the route selected to the summit. On a mountain of such an enormous scale we shall be able to avoid difficult rock climbing. But I think every one of us will have to call up all he ever knew about snow conditions. These, to my mind, will prove one of our main difficulties. I do not mean we need fear avalanches coming down on us, for no good mountaineer recklessly ventures in their path. The great danger will be that at altitudes such as we hope to reach, we may meet with conditions of snow such as none of us has ever seen, of such a dry and powdery nature that all our previous experience of the angle at which snow may be ascended, still less crossed diagonally, may go for nothing. As to the question of altitude, Mr. Meade actually camped at 23,600. Dr. Kellas and Captain Morshead reached the same place last year without feeling any inconvenience. Indeed, Captain Morshead goes so far as to say he could have gone several thousand feet higher.

"I earnestly hope it may be my good fortune to be one of Captain Morshead's companions in overcoming the 6,000 feet still to be made. Dr. Kellas has recently carried out a valuable series of temperature observations at altitudes varying from 15,000 to 22,000 feet. By a process of extrapolation one can calculate from these data that temperatures of 60° fahr. are quite likely, indeed highly probable, on the summit of Mount Everest. In other words, the cold on this expedition will in all probability be arctic in its intensity. That in itself may not at first be considered a very serious matter, but it must be borne in mind that at high altitudes which must be attained the rate of evaporation of moisture and the loss of heat from the human body will be far greater than at sea level.

"One other question, and one which, as far as I am aware, was first recognized by Mr. Meade, is of great importance, and that is the effect of the exposure of the body to ultraviolet light. At high altitudes there are large quantities of ultraviolet light not kept back by the atmosphere. At low sea level we are protected. Ultraviolet rays impinging on the skin literally burn it, and the burning is followed by a feverish condition which hardly seems to me to be conducive to health and well-being."

Other writers in the same journal deal with the question of supplies, scientific investigations, photography, etc., but the exigencies of space forbid a fuller account of this highly scientific and eminently sportsman-like expedition. Meantime Mt. Everest, cold and calm in the heart of Asia, awaits the slow but sure footfalls of the Anglo-Saxons. May their efforts help to round out the achievement of Admiral Peary and establish the pre-eminence of English speaking explorers, and may they all return safely from this most perilous enterprise.

CRYOGENIC LABORATORY OF THE BUREAU OF MINES

ON the twenty-first of May the new Cryogenic Laboratory of the Bureau of Mines was opened, the equipment having been supplied from funds allotted to the Bureau from the Navy, the Army Air Service, and the Bureau of Mines. The object of the laboratory is to obtain scientific data that will be of use in the operation of the helium plants, an effort to obtain more efficient operation and to reduce further the cost of helium.

A second object is to furnish facilities to scientists who are interested in very low temperature work, particularly along the lines not covered in the Bureau's present program.

At present vapor pressure work in connection with the ternary mixtures and the purification of helium with charcoal at low temperatures constitute a part of the work. It has already been found that charcoal has a selective absorption at low temperatures removing nitrogen but not absorbing helium. This property has been utilized in purifying helium both from nitrogen and from the air.

The importance of purity is unusually great as the difference between 100 per cent helium and 94 per cent is very great when expressed in lifting power and range of operations for a helium-filled balloon. The Army has constructed a repurification plant on railroad cars and the Bureau of Mines will install a charcoal unit testing out the entire device before it is installed on the car.

Courtesy of the Metropolitan Museum of Art

A GROUP OF GREEK VASES OF THE FIFTH AND SIXTH CENTURIES B.C. AT THE METROPOLITAN MUSEUM OF ART. THE ATHENIAN PYXIS, AT THE RIGHT DATES BETWEEN 470 AND 460 B.C. IT DEPICTS THE JUDGMENT OF PARIS

Dynamic Symmetry

The Rediscovery of the Basic Principles of Greek Art

NOT only the artist and the architect but the structural engineer and the devotee of pure science will find it of the greatest interest to follow the steps by which the well-known draftsman and illustrator, Mr. J. Hambidge, of New York has been led to formulate the remarkable theory of "dynamic symmetry," in which he believes he has rediscovered those principles which guided the artists of Greece's greatest period in the making of their imperishable works whether of sculpture, of architecture, or of pottery. These basic principles are, however, by no means artificial. On the contrary, they are those which underlie the proportion not only of the human frame, but of the growing plant.

Mr. Hambidge, who has been studying the subject with glowing enthusiasm for many years, has recently been in Europe gathering fresh data to support his views from the surviving masterpieces of classic art in old-world museums. Previous to sailing he devoted two years to the giving of a series of lectures at Yale and at Harvard and to special classes of artists, sculptors, designers and teachers in New York and in Boston. It is his purpose to publish a series of books dealing with the various phases of the subject. The first of these, which is entitled "Dynamic Symmetry," was recently published by the Yale University Press, which is also sponsor for the illustrated monthly magazine called *The Diagonal*, whose object is stated in its subtitle "An Illustrated Monthly Magazine devoted to the Explanation of the Rediscovered Principles of Greek Design, Their Appearance and Nature and Their Application to the Needs of Modern Art."

The first volume mentioned above deals entirely with Greek vases but it is the author's intention in the subsequent volume to deal with other phases of classic art, such as bronzes and marbles, decoration and architecture.

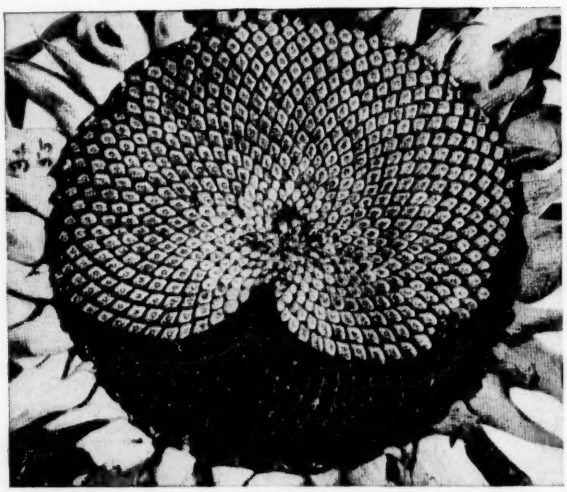
The study of the impersonal aspect of art in relation to the symmetry of natural form, was begun some twenty years ago, and it was found that there are only two types of symmetry found in nature capable of being employed in design. One of these types is termed "static" and the other "dynamic." The former is, of course, the simplest, thus the savage decorating his canoe, his blanket, or his earthen jug, uses static symmetry unconsciously, but it is impossible, says Mr. Hambidge, to make use of dynamic symmetry unconsciously. He finds that there were only two peoples, indeed, who made use of dynamic symmetry at all—the Egyptians and the Greeks. The former developed it possibly as early as the first or second dynasty, from an empirical or "rule of thumb" method of surveying. Some slight knowledge, too, of this form of symmetry was shown to the Hindus about the 5th or 8th centuries, B.C. The Greeks learned its principles from the Egyptians some time during the 6th century B.C. and they supplanted, probably quite rapidly, a sophisticated type of static symmetry then in general use among them. These master minds of the ancient world, however, soon developed the theory and practice of dynamic symmetry far beyond their masters and made the discovery, within a few years, that this symmetry is essentially identical with the symmetry of growth in the human being. Vitruvius, to whom we are indebted for such knowledge of the Greek principles of art, as has come down to us, declared that the Greeks *learned* symmetry from the human figure and applied it to their works of art, especially their temples. It is now believed, however, that Vitruvius was mistaken in this as in various other statements. The Roman architect had no knowledge of symmetry beyond a crude form of static symmetry. He declared, accordingly, that the Greeks used a modulus, *i.e.*, a definite unit of length, to determine the symmetry of their temples and gives elaborate instructions as to how the plans were developed. But Mr. Hambidge declares that no Greek design has been found which agrees with the statement of Vitruvius and he adds that the modulus could only produce a grade of static symmetry which a Greek would have found so crude as to be amusing.

Stated in brief *the essential principle of dynamic symmetry is that multiples of areas instead of multiples of linear units are involved.* In other words the architecture of a man or a plant must be studied from a *projection*, *i.e.*, from a two-dimension drawing; this projection always represents some arrangement of two-dimension form within a rectangle and these rectangles both individually and as a group possess marvelous properties of proportional subdivision.

An excellent idea of dynamic symmetry as found in a plant can be obtained by a study of the arrangement of the seed in the head of a sunflower.

THE PHENOMENON OF PHYLLOTAXIS

It has long been known that a special series of numbers is connected with the phenomenon of the regular arrangement found in the leaves of plants. This series is called a summation series from the fact that each term is composed of the sum of the two preceding terms, as follows: 1, 2, 3, 5, 8, 13, 21, 34, 55, etc. This subject is discussed in great detail in the well-known works by Prof. A. H. Church of Oxford, entitled "Phyllotaxis in Relation to Mechanical Law." This series of numbers in reality represents the symmetry of the plant in the sense that the word is used as "analogy," which is its Greek meaning. From this series we obtain the entire machinery of dynamic symmetry, which applies not only to the architecture of the plant but to the architecture of man.



SUNFLOWER HEAD SHOWING THE CURVES FOLLOWED BY THE SEEDS

This summation series of numbers, because of its character, represents a ratio, *i.e.*, it is a geometrical progression. This ratio may be obtained by dividing one term into another, such as 34 into 55. The series does not represent the phenomenon exactly but only so far as it is representable by whole numbers. A much closer representation would be obtained by a substitute series such as: 118, 191, 309, 500, 809, 1,309, 2,118, 3,427, 5,545, 8,972, 14,517, etc. One term of this series divided into the other equals 1.6180, which is the ratio necessary to explain the symmetry of the plant design system.

The operation of the law of leaf distribution and its connection with the summation series of numbers is explained by Professor Church, who uses as illustration the disk of the sunflower.

"The most perfect examples of phyllotaxis easily obtainable are afforded by the common sunflower, so frequently selected as a typical Angiosperm, both in anatomical and physiological observations, owing to the fact that it exhibits, par excellence, what is regarded as a normal structure little modified by specialization for any peculiar environment. Not only is the sunflower a leading type of the Compositæ which holds the highest position among Angiosperm families, but among this family it flourishes in the best stations, in which sunlight, air, and water supply are perhaps at an optimum for modern vegetation. The very fact that it is as near an approximation to the typical Angiosperm as can perhaps be obtained, suggests that the phenomena of growth exhibited by it will also be normal, and from the time of Braun to that of Schwendener it has afforded a classical example of spiral phyllotaxis."

The sunflower heads may be readily observed. By taking a head in which the last flowers are withering, and clearing away the corolla tubes "the developing ovaries are seen to mark out rhomboidal facets, and when the fruits are ripened, and have been shed, the subtending bracts still form rhomboidal sockets. These sockets, with or without fruits, form a series of interesting curves identical with those of the pine cone, only reduced to a horizontal plane.

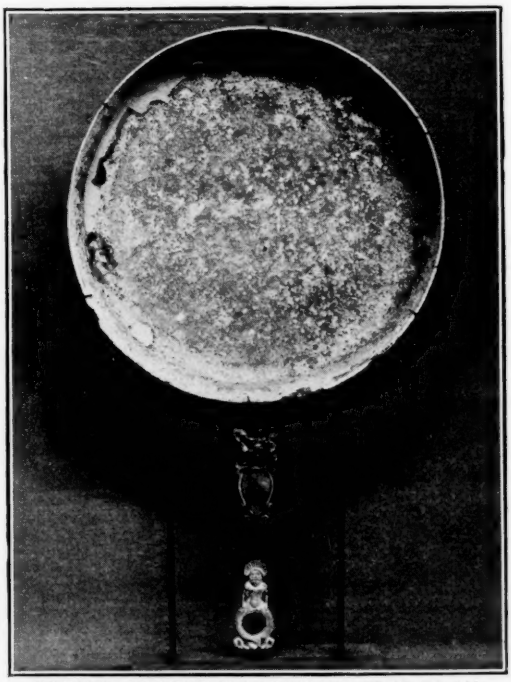
"A fairly large head, 5 to 6 inches in diameter in the fruiting condition, will show exactly 55 long curves crossing 89 shorter ones. A head slightly smaller, 3 to 5 inches across the disk, exactly 34 long and 55 short; very large 11-inch heads give 89 long and 144 short; the smallest tertiary heads reduce to 21 to 34 and ultimately 13 to 21 may be found, but these, being developed late in the season, are frequently distorted and do not set fruit well.

"A record head grown at Oxford in 1899 measured 22 inches in diameter, and, though it was not counted, there is every reason to believe that its curves belonged to a still higher series, 144 to 233. The sunflower is thus limited in its inflorescence to certain set patterns, according to the strength of the inflorescence axis, *e.g.*, 13/21, 21/34, 34/55, 89/144. These were first observed by Braun (1835), and translated into terms of the Schimper-Braun series they would correspond to divergencies of 13/34, 21/55, 34/89, 55/144, and 89/233, respectively. Under normal circumstances of growth, the ratio of the curve is practically constant. (Cf. Weisse. Out of 140 plants 6 only were anomalous, the error being thus only 4 per cent.)"

The ratio 1.6180, when reduced to a rectangular area makes a rectangle which has been given the name by Mr. Hambidge of the "rectangle of the whirling squares."

METHODS OF MANIPULATING THE PLANT FORMS OF NATURE

Mr. Hambidge's idea is that the most distinctive shape which we derive from the architecture of the plant and the human figure is a rectangle which has been given the name "root-five." It is so called because the relationship between the end and side is as one to the square root of five, 1:2.2360 plus. As a length unit the end cannot be divided into the side of a root-five rectangle, because the square root of five is



DYNAMIC SYMMETRY AS APPLIED EVEN TO AN ANCIENT GREEK FRYING PAN

a never-ending fraction. We naturally think of such a relationship as irrational. The Greeks, however, said that such lines were not irrational because they were commensurable or measurable in square. This, according to Mr. Hambidge, is really the great secret of Greek design. In understanding this measurableness of area instead of line the Greek artists had command of an infinity of beautiful shapes which modern artists are unable to use. The relationship between the end and side of a root-five rectangle is a relationship of area and not line, because as lengths one cannot be divided into the

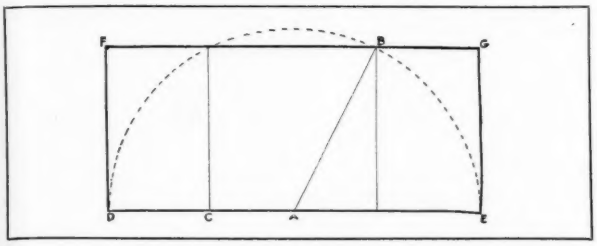


FIG. 1

other, but the square constructed on the end of a root-five rectangle is exactly one-fifth of the area of the square constructed on the side. The areas of rectangle which have this measurable relationship between end and side possess a natural property which enables us to divide them into smaller shapes which are also measurable parts of the whole.

THE ROOT RECTANGLE AND THE RECTANGLE OF THE WHIRLING SQUARES

The construction of a root-five rectangle is simple. Draw a square as BC in the diagram (Fig. 1) and bisect one side as at A. Draw a line from A to B and use this line as a radius to describe the semicircle DBE. AE and AD are equal to AB, or the line DE is twice the length of the line AB. Complete the rectangle by drawing the lines DF, EG. It will be noticed that the rectangle FE is composed of the square CB and two rectangles FC and BE. This is the *root-five* rectangle and its end to side relationship is as one to the square root of five, 1:2.2360: the number 2.236 being the square root of five. Multiplied by itself this number equals 5.

In Mr. Hambidge's theory this root-five rectangle is the basic shape of vegetable and animal architecture and is the form which has solved the mystery of the perfection of classical Greek art.

THE RECTANGLE OF THE WHIRLING SQUARES

The root-five rectangle produces a great number of other shapes which are measurable in area with themselves and with the parent shape. The principal one of these is that which is called by Mr. Hambidge *the rectangle of the whirling squares*. The relationship of this rectangle to the root-five rectangle is shown by its construction. Draw a square as CB in Fig. 2. Bisect one side as at A. Draw the line AB and make AE equal to AB. Complete the rectangle by drawing the lines BF, FE. This rectangle, DE, is the rectangle of the whirling squares. It is composed of the square CB and the rectangle BE. It is apparent that this shape is equal to the root-five rectangle minus one of the small rectangles FC or BE of Fig. 1.

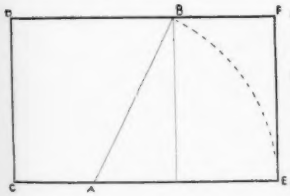


FIG. 2

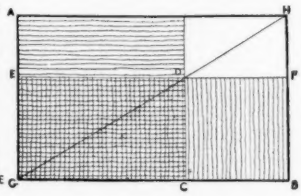


FIG. 3

As has been said above, the construction of the shapes of vegetable and animal architecture is simple and if we wished to begin using them in design little more would be necessary. Unfortunately we cannot afford to wait to discover all the wonderful properties possessed by these simple shapes by practically employing them in our design problems. Time is too short and our needs too great. But, fortunately, as Mr. Hambidge points out, we have the use of a tool which the Greek artists did not possess. That implement is arithmetic. "By the use of a little adding, multiplying, dividing and subtracting, we may expedite our progress enormously. This will be apparent if we consider the square of the root-five rectangle as representing one or unity; this may be 1. or 10. or 100. or 1000, but it will always be a square as an area of sides of equal length. Regarded thus it will be apparent that the area of any rectangle may be composed of one or more squares plus some fractional part of a square. The square root of five is 2.236; if one is subtracted from this number the result will be 1.236. In this case 1.236 represents the two small rectangles on either side of the square. If this number is divided by two, the result is .618. This number represents each one of the two small rectangles. We now see that the area of the root-five shape may be considered as 1 plus .618 multiplied by 2. Also it is now apparent that the area of the rectangle of the whirling squares may be considered numerically as 1 plus .618."

For the purpose of dividing up the areas of rectangles so that

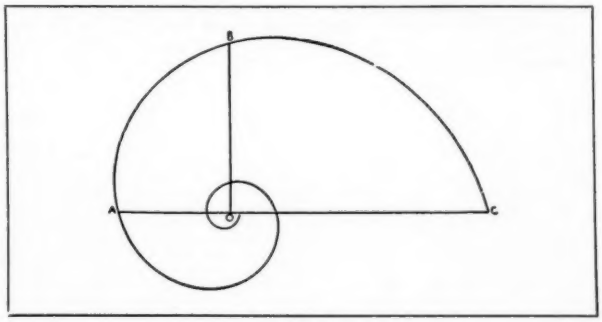


FIG. 4

the divisions would be recognizable, the Greeks had recourse to a simple but ingenious method which is called the "application of areas." (Fig. 3.) The idea was used by them both in science and in art. For a description of the process as used in science see any standard work on the history of Greek geometry. Classic design furnishes abundant examples of its use in art. The process in design may be illustrated by either of the rectangles described above. If to a rectangle of the whirling squares we apply a square on the end of that shape, the operation is equivalent to subtracting 1. from 1.618. A square on the end applied to the area of a whirling square rectangle leaves as a remainder a .618 area. If a square on the end of a rectangle is applied to its side, however, the operation is not so simple unless we use the Greek method. This process is shown in diagram Fig 3.

"To the rectangle AB the square on the end AC is applied. To apply this same square to a side as BC we must first draw a diagonal to the whole shape as GH. This diagonal cuts the side of the square AC at D. Through the point D we draw the line EF. The area EB is equal to the area of the square AC. This process applies to any rectangular area whatever which may be applied to either the end or the side of a rectangle. It will be noticed that the square on the end of a rectangle when applied to a side changes its shape, *i.e.*, it is no longer a square, though equal in area to the area of a specific square. It is clear that now it is composed of a square plus some other area which may be composed of either a square or squares or some fractional part of a square. In the rectangles which we find in plant and animal architecture

and in Greek art this area of a square applied to a side of such shapes is always understandable or measurable in terms of the whole."

HOW DYNAMIC SYMMETRY WAS DISCOVERED

To the end that the artist may understand the essential idea connected with the form rhythms observable in plant architecture and apply it to his immediate needs, it is advisable to digress at this point and explain how observation of this from rhythm led to the discovery of Dynamic Symmetry. Many years ago Mr. Hambidge became convinced that the spiral curve found in *plants* which Professor Church describes in his work on the law of leaf distribution, and that of the curve found in spiral shells were identical and must be the equiangular or logarithmic spiral curve familiar in mathematics. In this connection the reader is referred to a paper by the Rev. H. Moseley "On the Geometrical Forms of Turbinated and Discoid Shells" (Phil. Trans., pp. 351-370, 1838), and to the lucid treatment of the spiral by D'Arcy W. Thompson. ("Growth and Form," Cambridge, Eng., 1917.) Being convinced that the spiral was indeed the mathematical curve mentioned Mr. Hambidge saw that, because of a certain property which it possessed, this spiral could be reduced from a curve to one composed of straight lines and thereby be used by the artist to solve certain problems of composition and connect design closely with nature. This property of the curve is expressed as follows: Between any three radii vectores of the curve, equal angular distance apart, the middle one is a mean proportional between the other two. The drawing,

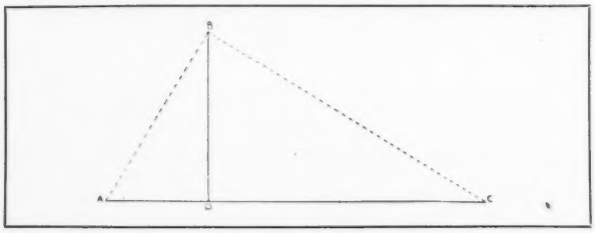


FIG. 5

Fig. 4, explains this. O is the pole or eye of the curve and the lines OA, OB, OC are radii vectores equal angular distance apart. In this case the angle is a right angle. According to the definition the line OB is a mean proportional between the other two, *i.e.*, OA and OC. This means, speaking in terms of area, that the line OB is the side of a square equal in area to a rectangle the end and side of which are the lines OA and OC. It necessarily follows, therefore, that if three lines stand in this relationship they constitute the essentials of a right angle. This is shown in Fig. 5. The line OB is a mean proportional between the lines OA and OC and the shape ABC is a triangle, right-angled at B, and the line AC is the hypotenuse. One of the earlier geometrical facts determined by the ancient Greeks was that in a right-angled triangle a line drawn from the intersection of the two sides to meet the hypotenuse at right angles was a mean proportional between the segments of the hypotenuse. Simply stated, this means that three lines situated like the three radii vectores mentioned constitute three terms of a continued proportion; OA is to OB as OB is to OC. The relation between these lines could be stated arithmetically as a ratio, this following from the fact that lines in continued proportion form a geometrical progression. If we assume, for example, that the ratio is 2 and the length of the line OA is two units then the line OB would be four units and the line OC eight units. 2, 4 and 8 constitute three terms of a simple proportion with a ratio of 2 and according to the rule of three, the square of the mean is equal to the product of the extremes. In this case 4 is the mean and 2 and 8 are the extremes. 4 multiplied by itself, or squared, equals 2 multiplied by 8. The mean is the side of a square equal in area to the area of a rectangle made by the extremes or 2 as end and 8 as side. But the line OB (Fig. 6) may be produced through the pole O of the spiral until it touches the curve at the point D and DAB will be a right angle and there will exist four lines in continued proportion, OD, OA, OB and OC. Also the curve cuts the vector lines at E and F, etc., and other right angles are created. In short, the curve may be reduced from a curve to a rectangular spiral (Fig. 7) and, as in the curve, the converging right angles wrap themselves to infinity around the pole. This particular curve never reaches the pole, it goes on forever.

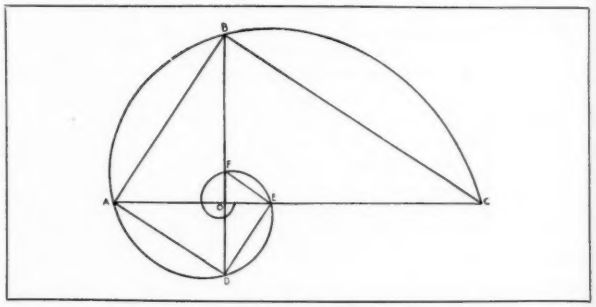


FIG. 6

The essential point is that this simple construction enables the designer to introduce the law of proportion into any type of composition and that, too, in much the same way as it appears in the plant and the shell. The operation by which this is accomplished is the drawing of a diagonal to a rectangle and a line from one corner cutting this diagonal at right angles (Fig. 8) is any rectangle and AB is a diagonal. The line CD, drawn from the corner C, cuts the diagonal AB at right angles at O. It is apparent that the angular spiral formed by the lines AC, CB, BD, DE and EF is identical with the angular spiral derived from the shell and from the plant. Having established a condition of proportion within the area of a rectangle it becomes obvious that the line CD must perform some important function. Artists are well acquainted with at least one property of the diagonal to a rectangle. It is well known, for example, that any shape drawn within the area of a rectangle whose diagonal is common to the diagonal of the containing area is a similar shape to the whole. This geometrical fact is utilized in the arts, especially the reproductive arts, for the purpose of determining similar shapes on a larger or smaller scale. This, however, is about as far as modern artistic knowledge of proportion

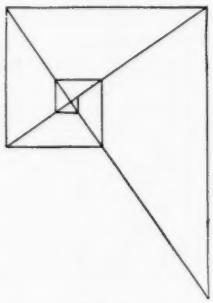


FIG. 7

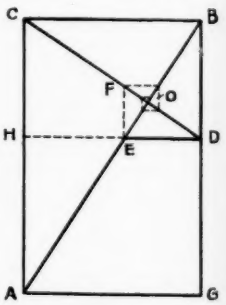


FIG. 8

extends. The value of the line CD is unknown to modern art. That the value of this was known at one time in the history of art and its power appreciated is abundantly proven by dynamic analysis of classical Greek design. This line CD determines the reciprocal of a rectangular shape and is itself the diagonal of that shape. Following the construction we appreciate the fact that, in a rectangular area, the diagonal of a reciprocal cuts the diagonal of the whole at right angles. The line DH (Fig. 8), which is drawn parallel to the ends

AG or CB, fixes the area of the reciprocal of the shape AB. With this notion of a reciprocal in mind it is apparent that the fatter or squatter the rectangle the larger will be the area of the reciprocal. For example, if instead of the rectangle AB of Fig. 8, one is constructed which much more closely approaches the shape of a square, the area of the reciprocal, because it is a similar shape to the whole, will also much more closely approach the shape of a square. The breadth of the reciprocal increases with the breadth of the partner form until it coincides with it as a square; or it decreases until both become a straight line. Obviously, also, there must be rectangles such that the reciprocal is some even multiple of the parent form, such as 1/2, 1/3, 1/4, 1/5 and so on. Perception of this fact led Mr. Hambidge to discover the root rectangles. It was found that a rectangle whose reciprocal equaled one-half the whole was a root-two rectangle; 1/3 a root-three, 1/4 a root-four and 1/5 a root-five rectangle and so on. When the root-five rectangle was defined and its commensurable area examined it was found that this shape was connected in a curious manner with the phenomena of leaf distribution. As has been explained, the ratio produced by the summation series of numbers which so persistently appears in the rhythmic arrangements of leaves and seeds in vegetable growth is 1.6180. When a rectangle was made wherein the relationship between the end and side was the ratio 1.6180 it was found that the end of the reciprocal of this area equaled .618. The side of a root-five rectangle, arithmetically expressed, is 2.2360 or the square root of five. If the ratio 1.6180 is subtracted from 2.2360 the remainder is .6180. The area of a root-five rectangle, therefore, is equal to a 1.6180 rectangle plus its reciprocal. The 1.6180 rectangle, because the end of its reciprocal equals .618, is a rectangle such that its *continued* reciprocals cut off squares and these squares form a spiral around a pole of that rectangle. This pole, of course, is the point where the diagonal of a reciprocal and a

Courtesy of the Metropolitan Museum of Art

A GREEK STAMINOS BELONGING TO THE FIRST HALF OF THE 5TH CENTURY B.C.

diagonal of the whole cross each other. Because of this property this shape was given the name "the rectangle of the whirling squares."

DYNAMIC SYMMETRY AND GREEK POTTERY

The museums both here and abroad are particularly rich in Greek vases, large numbers of which have been found in the archaeological excavations. Many of them, too, are admirably preserved and, for this reason, they are peculiarly well adapted to the exemplification of Mr. Hambidge's views. As stated above the first volume of his projected series is devoted entirely to a study of the Greek vase, and it contains over 200 carefully made analytical drawings of vases, most of which are included in the collections of the Metropolitan Museum of this city, the Boston Museum of Fine Arts, and

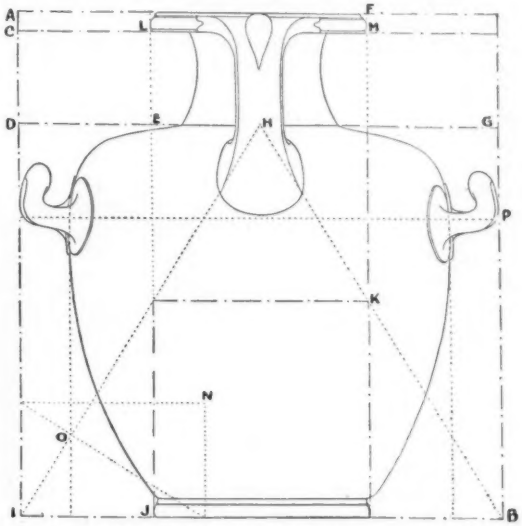


FIG. 9. A GREEK HYDRIA ANALYZED BY MR. HAMBIDGE

the Yale Museum. They include the chief forms, the amphora, the kylix, the pyxis, the krater, the lekythos, and the lebes. Each of these delicate works of art forms a beautiful composition in which the various details repeat the primary theme, thus producing a unified harmony. In other words the rectangles made by the width and the height of the lip, the neck, the body, the foot, and the handles, respectively, bear a definite mathematical relation to the rectangle which contains the vase as a whole. In the words of Gisela M. A. Richter, of the staff of the Metropolitan Museum of New York City, "We have an interplay of areas comparable to the sequence of phrases in a musical composition." Miss Richter, by the way, calls attention to the fact that in spite of the exact mathematical dimensions involved the scheme is in no way a mechanical device, but merely a useful framework within which the artist's imagination has free play. She remarks, finally, "It no more impedes individuality than harmony obstructs the composer or a metric system the poet. It merely supplies that sense of law and order which we know to be one of the dominant characteristics of Greek art."

Our illustrations include some of the beautiful specimens in the Metrpolitan Museum copied and analyzed by Mr. Hambidge.

THE DYNAMIC SYMMETRY OF THE HUMAN FIGURE

The limits of this brief article forbid us naturally to give an extended account of Mr. Hambidge's minute and careful study of the applications of his theory to the human figure, but it is worth while attempting to give in brief the main features of his method of study. He begins by making the rather startling statement that human anatomy as now taught in art schools, is of little if any use to the artist. The only anatomy the artist requires to have a knowledge of is of a type which brings out the *larger pattern forms of the structure of the body.* He declares explicitly "surgical anatomy leads to an overstress of detail and a violent squirm and twist of the figure incompatible with noble design. The Greeks used the correct type of anatomy. But we must not study Greek anatomy by itself; we must study nature and use Greek knowledge to explain something of the subtlety of construction and the beauty of man's structure." He tells us further that the great span ratio or index for the average man

i.e., the distance between the tips of the middle fingers when the arms are fully extended is 1:1.045. This index is determined by dividing the height of the individual into the span and the average quoted was found by summarizing the measurements of thousands of persons. This average, of course, is often exceeded in well-built individuals. There is in the Museum of the Harvard Medical School a remarkable skeleton of a man who must have been nearly six feet tall when living. The great span of this skeleton makes with the full height a double root-five rectangle. This gives a span ratio of 1:1.108. But this ratio is the square root of 5 divided by 2; 2.236 divided by 2 equals 1.118. "This is the ratio of a rectangle which was used repeatedly by Greek artists, as is shown by some of the finest examples of design which have survived. The rectangle, which encloses the side elevation of the head, is also a double root-five rectangle. The rectangle which encloses the torso and head is a root-five rectangle. Moreover, the length of every bone in the example is expressible arithmetically in figures of the dynamic symmetry series if the measurements are made with a metric scale."

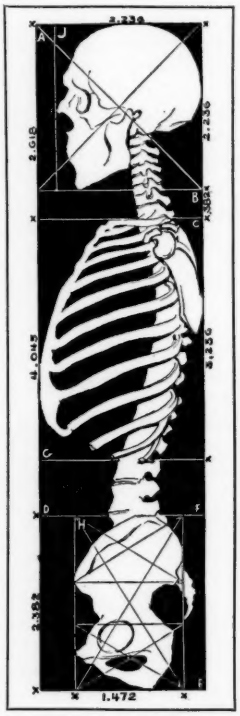


FIG. 10. ANALYSIS OF A SKELETON IN THE HARVARD MEDICAL SCHOOL

Mr. Hambidge makes use of the skull of this same skeleton as a subject of analysis and his method will be of interest especially to students of art. Before a skull or a head from a living model can be measured so as to establish a rhythmic area theme, it is necessary to draw a line across it, which will definitely fix it at right angles to the erect position of the figure. This line represents what anthropologists call a plane. Various authorities have employed no less than fifteen different skull planes but Mr. Hambidge has found the best one to be that drawn from the center of the opening of the ear to the upper ridge of the bottom bone of the eye socket. When this line has once been fixed the rectangle of either the front or side elevation is easily determined. The importance of this line is due to the irregular nature of the skull or the head. Without this line the skull may be fitted into many rectangles, according to the degree to which the chin is raised or lowered. But with this basic line once settled, there is only one rectangle for the side and one for the front elevation. In the author's words: "When we find that these two rectangles are logical elements in an encompassing rhythmic theme in commensurable area which takes in every detail of the human structure, we may feel confident that we are proceeding correctly."

WONDERS OF THE ENAMELER'S ART

By J. H. DAVIES

FROM the days of the construction of the magnificent enameled brick walls of the palace of Rameses III., at Tel el-Yehudia, in the delta of the Nile, to our own time, the art of emaneling has engaged the efforts of workers in precious materials. And the art of decoration in enamel is as universal as it is ancient. Its history can be traced through the centuries and throughout the eastern and western worlds alike. It has left us such relics as the walls of the palace of Nimrod, in Babylon; the enameled gold and silver ornaments of Greece and Rome; the barbarously beautiful enameled horse trappings, weapons and jewelry of the ancient Celts and Saxons. Byzantium, Cologne and Limoges became famous centers of the art; and 14th century Italy raised it to previously unattained heights.

Until this time, and even further, to the end of the 15th century, all enameling had been of the cloisonné type, the "cloisons," or little metal-bounded compartments containing the enamel having been believed necessary to preserve the form of the designs and separate the colors. But now came the solid enameling of metal surfaces as well as various other developments. Translucent enamels, painted enamels, and enamels revealing engraved designs on the underlying metal were perfected. Very recently Mr. Alexander Fisher, well known for his exquisite enamels, has perfected the art of making a solid enameling from which the metal backing is then removed, producing a clear transparent subject in color. He has also been successful in producing a colored enamel relief resembling the Della Robbia relief, save that the color of the enamel by its nature permeates the whole depth of the relief, whereas in the Della Robbia ware it is only on the surface. It also has a fresco, or dull-finish, instead of a highly-glazed surface.

There has recently been a great commercial stimulus to the art of enameling. Just before the war this activity reached a point never before attained. Throughout Europe and in the United States and Japan the production was great. One o fthe phases of the unusual interest was a demand for imitations of old pieces, especially of old Chinese work. As Chinese cloisonné has always been deservedly admired, it is interesting to recall the process used in making it.

Ancient enameling was done on gold, silver and other precious metals. Today, however, the foundation most in use is red copper. The drawing of the intended decoration is first sketched on paper. In the Hall of the Living Tribes of Asia, in The American Museum of Natural History, in New York City, the entire cloisonné process is shown by means of pieces of work in successive stages and a printed explanation. The first step is the colored design on paper. Then the design is transferred to the vase to be decorated by tracing with a stylus. A net-work of thin flat copper wire, following the outlines of the tracing is fastened to the vase by means of a kind of glue prepared from root of orchid. For this purpose, resin is sometimes used. To hold the spirals of this wire-outlined design in place, tiny fragments of a very hard refractory substance are inserted between them at regular intervals. The whole is then powdered over with a compound made of silver filings, copper and borax. The vase is now enclosed in an iron vise or ferrule, placed in the middle of an iron-wire cage filled with charcoal. It is exposed to the fire for 15 minutes, a perfect soldering being thus achieved. The piece is then taken from the fire and washed in an acid decoction of apricots with a brush. It is now ready to receive the enamel.

Into the cell-like compartments, or "cloisons," as they are technically called, formed by the windings of the copper wire, the enamel paste is introduced by means of a tiny iron trowel, the colors of the paste used corresponding to the colors of the design. When this process is finished, the vase is again fired. This operation requires great experience in determining the proper hardening point of the pigments. One firing requires not more than 10 minutes but does not always suffice to produce an even enameling over a large piece. Bubbles may appear, which have to be removed with a nail and little hammer, and the depressions are again filled with the proper colors. The Museum exhibit shows vases after various firings of this kind. Sometimes eight firings are required, the number depending on the colors and shades of color the enameler is seeking to produce.

The last step consists of polishing with a steel file. To render the surface uniformly even, further polishing is done with sandstone and lime-tree charcoal, while the vase is revolved on a lathe. Nothing now remains but the gilding of the interior of the vase, which at present is done exclusively by the galvanoplastic method instead of in the old-fashioned way with mercury.

The Elastic Force of Muscles*

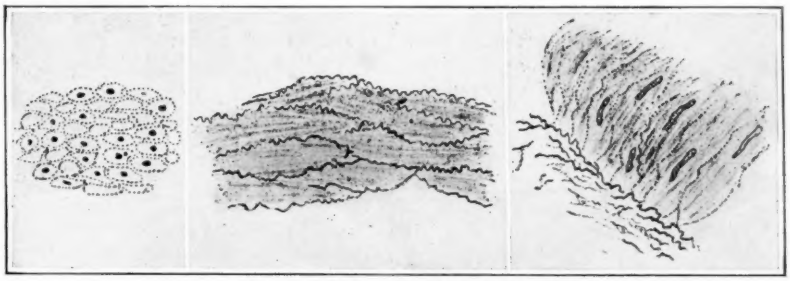
The Marvelous Artisans to Which We Owe All That the Hand of Man Has Accomplished

By Professor I. Athanasiu

Of the Faculty of Sciences of the University of Bucharest and Rector of the University

THE muscles of the body, especially those which possess striated fibers, are organs which have occasioned an immense number of investigations, some of which have concerned their structure while others, far more numerous, have dealt with their functions. There is nothing surprising in this when we recall the exceedingly important rôle which they are called upon to fulfil, not merely in the life of the individual but also in that of human society itself. To these marvelous artisans, indeed, we owe in the last analysis all that the hand of man has been able to accomplish.

In the following pages we propose to treat in a general fashion of the elastic force of the muscles. To this end we shall first examine the organ which develops this force and later, the part which it plays in the transformations of energy of which the muscles are the seat while engaged in fulfiling its proper function.



FIGS. 1 TO 3. ELASTIC FIBRILLAE SURROUNDING MUSCULAR FIBERS

1. Transverse section of smooth muscular fibers in the large intestine of a dog. The dotted lines represent the transverse section of the elastic fibrillae. 2. Longitudinal section of the smooth muscular fibers of a dog's bladder. 3. Oblique section of the smooth muscular fibers in the upper part of the stomach (cardia) of a horse

I.—THE ELASTIC ORGANS OF THE SMOOTH AND OF THE STRIATED MUSCLES

The majority of the studies made of the structure of smooth and of striated muscular fibers have had for their object their contractile substance, properly so called. But comparatively little work has been done with respect to the relations between this substance and the elastic and conjunctive tissues which surround it. Thus, the elastic fibers in the smooth muscles have been extensively studied by Treitz in 1863, Flemming in 1868, Baltzer in 1882, Drasch in 1894, Schaffer in 1899, Smirnow in 1899, Holmgrem in 1905, Mironesco in 1919, Trautmann in 1909, Lieto-Volaro in 1909, etc.; and the striated muscles have been studied by Martinaotti (1888) and Ranvier (1880 and 1890). This last histologist pursued the elastic fibers even up to their insertion upon a sarcolemma. Retterer and Lelièvre (1919) have gone still further and have described an elastic network or reticulum in the contractile substance itself of the striated fibers.

But the researches of these authorities have not succeeded in refining the intimate relations which exist between the muscular fibers, whether smooth or striated, and the elastic elements. This is readily explained when we recall the extreme delicacy of these elements at the point where they come in contact with the muscular fibers, which makes it impossible for them to be indicated by means of the various dyes employed in these researches. The case is analogous to that of the neurons whose delicate prolongations escaped the notice of histologists so long as they depended solely upon the usual dyes to render them visible. It did not become possible to observe them until the discovery of the impregnation by silver chromate (Golgi) and by reduced silver nitrate (Cajal) which make the most minute nervous fibrillae absolutely black. In the same way the elastic fibrillae which are so refractory to most of the dyes employed in histology do not become visible until impregnation is employed.

In the researches made by me with the assistance of M. M. Dragoin and Ghinea upon the smooth muscles, and with that of the former upon striated muscles, we have employed Cajal's method, *i.e.*, impregnation by reduced silver nitrate, slightly modified.

II.—THE ELASTIC TISSUE OF SMOOTH MUSCLES

Each muscular fiber is surrounded by an envelop of elastic fibrillae, arranged parallel to its great axis, as can readily be seen in Figs. 1, 2 and 3. The first represents a transverse section of smooth muscular fibers, and the black dots which surround each fiber represent the transverse sections of the elastic fibrillae of the envelop. Fig. 2 shows the longitudinal section of the smooth muscular fibers between which we see the elastic fibrillae. Fig. 3 exhibits an oblique section of a smooth muscular bundle and we may observe how an *inter-fascicular* elastic fiber sends out very fine fibrillae which penetrate among the muscular fibers.

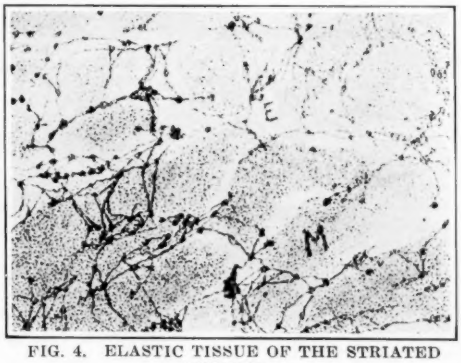


FIG. 4. ELASTIC TISSUE OF THE STRIATED MUSCLE

M, striated muscular fiber; *E*, perfibrillary elastic network

When we reconstitute, by means of these three sectional views, the smooth muscular fiber it appears to us as surrounded by a sheath formed of elastic fibrillae arranged lengthwise and exactly molding the body of the fiber. These elastic sheaths or envelops interlace with each other (anastomosis) to form a very closely woven *intra-fascicular* elastic system which is in direct continuation with the *inter-fascicular* system, as is the latter with the elastic system of the surroundning conjunctive tissue. All of the muscular and conjunctive elements of an organ having smooth fibers are enclosed therefore in a vast elastic network, and are continued without interruption in the thickness of the organ.

III.—THE ELASTIC TISSUE OF THE STRIATED MUSCLES

Impregnation by reduced silver nitrate shows in the first

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place that the sarcolemma is composed of three layers: an external layer of conjunctive nature, whose fibrillae are derived by the dissociation of the inter-fascicular conjunctive fibers (Fig. 4 M); a middle layer of elastic nature whose fibrillae interlace to form a network (Fig. 4 E); and an internal layer of homogeneous aspect which is in immediate contact with the contractile substance and which is formed by a mingling of elastic and conjunctive tissue.

But in these fibers we may go still further and see in the contractile substance itself grains which become impregnated

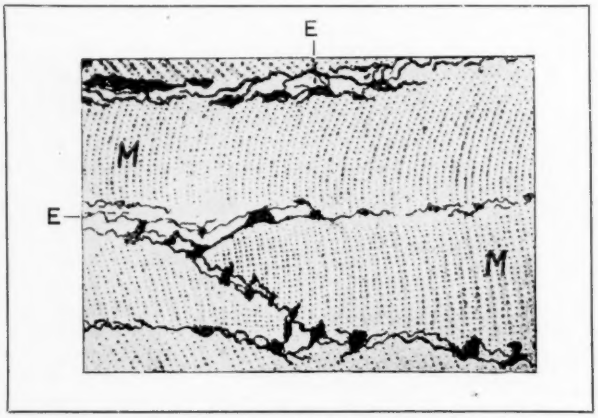


FIG. 5. GRAINS IN THE CONTRACTILE SUBSTANCE

M, striated muscular fiber showing the grains of the impregnated clear zones: *E*, elastic fiber and nodes of their anastomoses

like the elastic tissue. They occupy the light-colored bands in two rows on one side and the other of the stria of Amici (the thin disk) in Fig. 5. In the dark disk we see a single row of grains, much smaller, which are also impregnated by the reduced silver nitrate and which correspond to the membrane Z, or intermediate stria of Hensen (Fig. 6 H). Their impregnation coincides generally with that of the conjunctive tissue which impels us to believe that they contain more collagen than elastine. It separates the two rows of rods which compose the substance of the dark disks, as has been shown by Ranvier, the great master of modern histology, as well as by Retzius and Van Gehuchten later. Each of these rods, therefore, is attached at one end to the membrane Z (the intermediate stria of Hensen), and at the other end to an elastic grain, an arrangement shown in the diagram of Fig. 7.

IV.—EXPERIMENTAL PROOF THAT THE GRAINS SHOWN IN THE CLEAR BAND ARE ELASTIC

Ranvier was the first to recognize the fact of the elastic properties of the clear bands of the striated muscular fiber, basing his opinion on the one hand upon their enlargement in extended muscles, and on the other hand upon the fact that they are mono-refractive like elastic yellow tissue.

We have tried to discover whether the grains which enter into the constitution of the clear bands, and which exhibit the same affinity for the reduced silver nitrate as does the elastic tissue, partake of the property of the latter. To this end we made the following experiment: Three portions of the same striated muscle were subjected to the impregnation in three different states; the first in its natural length, the second extended, and the third contracted. In these three preparations the form of the grains is different. They are spherical in the first, which comes from the muscle in a state of repose (Fig. 5); they are elongated in the direction of the greatest diameter of the fiber in the second, which comes from the stretched muscle (Fig. 6); and they are elongated in the transverse direction of the muscular fiber in the third, which is taken from the muscle fixed in a contracted state (Fig. 8).

This experiment shows that the grains in the clear band undergo a change of form under the influence of the forces which act upon them; *i.e.*, the tension or contraction of the striated muscular fiber. Hence they are elastic.

V.—RÔLE OF THE ELASTIC ELEMENTS IN THE FUNCTIONING OF THE SMOOTH AND STRIATED MUSCULAR FIBERS

The researches mentioned above having enabled us to determine the arrangement of the elastic elements in the muscles we are justified in regarding these elements as antagonistic springs of the contractile substance of the muscular fibers. This is their fundamental rôle, as was perceived by Ranvier, Retterer, and Lelièvre. In the smooth muscle the sheath of each fiber is deformed during contraction, and the elastic energy thus stored up in this sheath serves to bring the muscular fiber back to its initial length as soon as the contraction is at an end.

The sarcolemma of the striated fibers must have the same function. But since their return to their initial position must be far more prompt and rapid than in the case of the smooth fibers they have corresponding need of a more powerful spring, which explains the penetration of the elastic elements into the contractile substance itself, forming the clear bands mentioned above. Thanks to these the rods of the dark disk, which assume a globular form during the contraction, as Ranvier has shown, are quickly brought back to their cylindrical form.

The following experiment enabled Ranvier to catch this change of form of the dark disks during the contraction: the *sartorius* muscle of a rabbit was strongly extended and then placed in a tetanic condition by means of a strong induction current. A solution of osmic acid was then injected at once into its mass. The muscle was thus fixed in a state of excitation, but without being shortened. In the preparations obtained from this muscle and sketched by Ranvier can be seen the rods of the dark globular disks, when the clear bands are greatly elongated. This experiment provided the basis of his theory with respect to muscular contraction, according to which the dark disks are the active elements of the striated fibers, since the contraction of these fibers is due to the for-

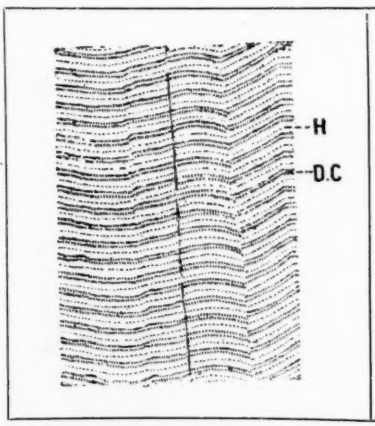


FIG. 6. STRIATED MUSCLE OF A RABBIT STRETCHED AND STIMULATED

DC, clear zone in which the grains are elongated in the direction of the diameter of the muscular fiber; *H*, intermediate stria of Hensen

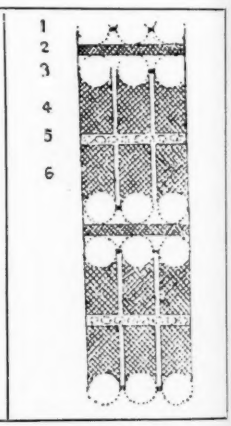


FIG. 7. DIAGRAM OF STRIATED MUSCLE

1, Clear semi-disk; 2, stria of Amici; 3, clear semi-disk; 4, dark semi-disk; 5, stria of Hensen; 6, dark semi-disk

mer's change of form. In becoming spherical they exert a pull upon the clear bands, causing these to become longer.

But the theory thus formulated applies to the aforesaid case of the muscles which is excited but at the same time prevented from becoming shorter and this, of course, does not represent the normal method in which this organ functions. When fixed in the state of free contraction, *i.e.*, accompanied

with a decreasing length we observe, on the contrary, that the clear bands are diminished in height and are elongated in a transverse direction, as was proved by our experiment described above (Fig. 8). Hence all the elements of the striated muscular fiber becomes shorter during its contraction; consequently its mechanism is properly explained in the following manner: The rods of the dark disk which are cylindrical while in a state of repose tend to become spherical during contraction but without undergoing a change of volume; obviously, therefore, they compress the elastic grains of the clear band which is elongated in the transverse direction of the muscular fiber; this elongation is also assisted by the

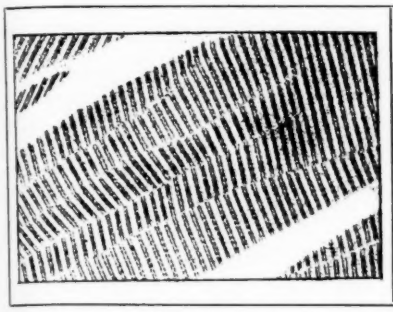


FIG. 8. TRANSVERSE SECTION OF STRIATED MUSCLE FIXED IN A CONTRACTED STATE

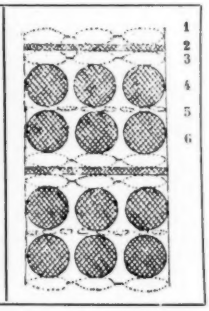


FIG. 9. CONTRACTED STRIATED MUSCLE—COMPARE WITH FIG. 7

sarcolemma which pushed outward by the swelling of the dark disks exerts a pull upon the clear bands.

The changes undergone during contraction by the dark disks and the clear bands are shown in Fig. 9. The elastic force stored up in the grains of the clear bands thus deformed serves to elongate the rods of the dark disk as soon as the contraction ceases.

There is no need, therefore, in order to explain the mechanism of contraction of the striated muscular fibers to assume either the expulsion of liquid matter by the dark disk as was believed by Krause and even by Ranvier as late as 1890 or, an absorption of liquid by this disk as was thought to be the case by Engelmann. This mechanism can be readily explained by the play of forces: the contractile force of the rods of the dark disk and the elastic force of the grains of the clear band.

VI.—THE ELASTIC FORCE OF THE SMOOTH AND THE STRIATED MUSCULAR FIBERS AND THE MECHANICAL WORK THEY PERFORM

The memorable experiments by Marey showed the utility of interposing an elastic spring between the motor and the weight to be displaced, for the potential energy stored up in this spring during its elongation would have been lost in the form of heat if the force of traction had been exerted without the intervention of the spring. Indeed this elastic energy not only greatly diminishes the shocks due to the inertia of the body, at the moment of its passage from the state of rest to that of motion, but by acting continuously upon this body it is converted into useful mechanical work done, and this augments the yield of the motor.

In the smooth muscles the elastic energy stored up in the sheath of each fiber is expended entirely to bring the latter to its initial length every time that its longitudinal diameter has been diminished with respect to its length in a state of repose (Fig. 10 *a* and *b*). But if the smooth muscular fibers happen to be distended by the contents of the viscera of which they form a part (Fig. 10*c*), then the elastic force of their sheath is added to that produced by the contractile surface in order to set in motion the aforesaid contents. It is converted therefore, into useful mechanical work done.

In the striated muscles the clear bands must diminish the shocks due to the passing of the contractile rod from the cylindrical form to the globular form. As for the conversion into mechanical work done of potential force stored up in the grain of these bands, this cannot be done by reason of the fact that this force acts during the elongation of the muscular fiber and not during its shortening which alone is capable of performing mechanical labor. It follows from this that the elastic force of the clear band is entirely expended to bring back the contractile rod of the dark disks to their initial length.

VII.—THE ELASTIC FORCE OF THE SMOOTH AND THE STRIATED MUSCULAR FIBERS AND THEIR COEFFICIENT OF ELASTICITY

It was long ago proved by physiologists that the elastic force of the striated muscle diminishes during its contraction, *i.e.*, that the same charge produces a greater elongation of the contracted muscle than of the muscle in a state of repose.

This diminution of the coefficient of muscular elasticity during a state of activity finds an explanation, in our opinion, in the potential energy which is stored up by the grains of the clear bands. This energy, in fact, which is due to their flattening (Fig. 8, contraction), is antagonistic to that developed by the contractile rods and in the same direction as the force which is seeking to lengthen the muscle. We can readily understand, therefore, that to produce an equal amount of elongation a lesser force of traction is required for the contracted muscle than for the muscle at rest, since the former is assisted by the elastic force of the clear band.

VIII.—ELASTIC FORCE AND MUSCULAR HEAT

The changes in the form of the elastic elements of the muscles must inevitably exert an influence upon the evolution of heat which takes place during their activity. It is well known in fact that the deformation of certain elastic bodies is accompanied by the absorption of heat. This is true of rubber which develops heat when stretched or compressed.

Elastic tissues behave in the same manner and we were convinced of this by experimenting upon the yellow cervical ligament of the ox. Thermo electric weldings (Constantan + iron) when placed in this ligament always exhibits a rise in temperature when the ligament is stretched and compressed, and the heat is proportional to the force exerted.

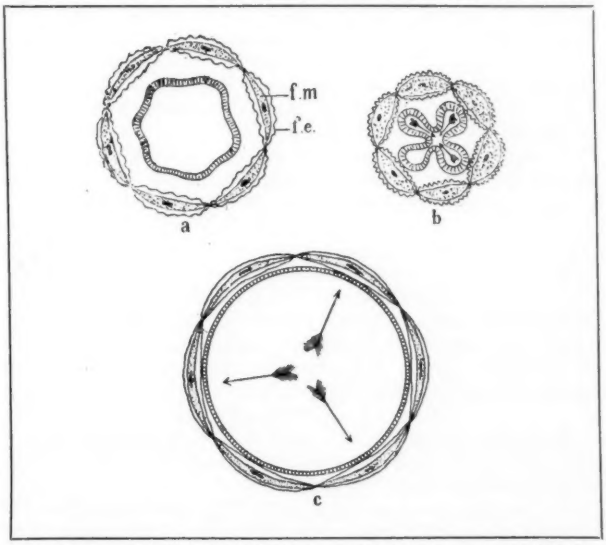


FIG. 10. DIAGRAM SHOWING FUNCTIONING OF ELASTIC AND CONTRACTILE FIBERS IN THE VISCERA

a, at rest; *b*, contracted; *c*, distended by contents of the viscera (*f.m.*, smooth muscular fiber; *f.e.*, elastic fiber of the envelope)

In our opinion we may explain by the fact thus discovered the phenomenon observed by Hill, namely that the heat produced during a muscular shock attained its maximum liberation before the end of the said shock. Probably part of this heat proceeds from the elastic grains of the clear band, which having absorbed the heat while becoming flattened liberates it during relaxation.

The Human Body as a Heat Machine

Studying the Vital Processes by Determining the Amount of Heat They Evolve

HUMAN calorimetry is the science whose object is to measure the amounts of heat liberated by the body under various circumstances and to determine the relation between these heat values and other factors involved in the vital processes, some of which inhere in the organism itself, such as age, weight, etc., while others are dependent upon external circumstances, such as the amount and nature of the food taken in.

It was the great Lavoisier himself who first attempted in 1780 to measure the amount of heat set free by a living organism. Making use of guinea pigs for his experiments he first proved that animals throw off carbon dioxide when exhaling and he then attempted to prove that the heat liberated by a given animal was equal to that produced by burning an amount of carbon equal to that contained in the carbon dioxide exhaled.

He began by measuring the carbon-dioxide (CO_2) produced by a guinea pig in ten hours. The amount of carbon contained in this amount of the gas should be capable when burned of melting 326 gr. of ice. In his second experiment, which likewise continued for ten hours he enclosed the same guinea pig in a sort of box surrounded by ice. He thus obtained 341 gr. of water proceeding from the melting of the ice by the warmth of the animal's body. These figures appeared to the great scientist to be sufficiently close to confirm his hypothesis allowing for unavoidable error. As a matter of fact, however, the results were only partially exact and that they should have approximated each other even thus closely was due merely to a happy chance: Lavoisier performed his calculations upon the theory that the exhaled carbon-dioxide was produced from carbon in the free state as when coal is burned. But as we now know the carbon in the body is found in highly complex combinations, such as glycogen, various albumenoids, etc.; it is necessary, therefore, to consider the heat which goes to form the carbon-dioxide from the point of view of these complex molecules and not from that of free carbon.

A very simple example will make this quite plain: when carbon-dioxide is formed by the combustion of free carbon 94 calories of heat are produced according to the equation

$$C + O_2 = CO_2 + 94 \text{ cal.}$$

but when heat is produced by the combustion of carbon monoxide (CO) only 68.2 calories are produced according to the equation $CO + O = CO_2 + 68.2$ cal. Here we have a difference in heat production of 25.8 cal. But this is precisely the amount which represents the heat produced when carbon is burned to carbon monoxide instead of to the dioxide, according to the equation

$$C + O = CO + 25.8 \text{ cal.}$$

Whatever the path followed to bring the atom of carbon into the condition of CO_2, the total number of calories produced is always 94.

On the other hand the equations given above show that the amount of heat set free in the production of one molecule of CO_2 depends upon the previous condition of the atom of carbon, *i.e.*, whether this is free or already in a state of combination. But in the body and in all food stuffs the carbon is always present in combination and hence the proper way to measure the heat produced is to find the heat of combustion of the compounds in question by means of Berthelot's calorimetric bomb, and it is this amount of heat which must be a factor in our calculations and not the amount derived from the combustion of pure carbon as Lavoisier supposed.

But in spite of the defects in his methods he was able to recognize the fact (collaborating with Seguin) that the quantities of carbon-dioxide produced and the amounts of oxygen absorbed increased with an increase in muscular labor. It was not until 1895, however, that the first calorimetric measures of a human being were made, the work being done in France by Langlois and the subject of experiment being a child. In 1911 the French physiologist, Lefèvre, gathered together all the known data upon the subject in a notable treatise.

CALORIMETRIC CHAMBERS

A calorimetric chamber is so constructed as to make it possible to measure exactly the amount of heat set free during the period of the experiment by the subject of the latter and to weigh and analyze all the waste product produced during the same time.

While a number of these have been constructed both here and abroad the typical example is that made by Professor Atwater and used since his death by Professor Benedict. The chamber consists of a sort of an air tight box having a capacity of 1,400 liters. The subject is seated in an armchair within this box which is connected with a pair of scales placed outside. In this manner the observer can readily follow the variations in weight.

Since the Atwater calorimetric chamber has been often described and is well known in this country, we shall omit the description of it and merely give a statement of some of the results obtained in this country and in France.

It has been found that with a normal diet suitably rationed, 90 per cent of the food taken is utilized in the organism. An interesting point is that a vegetarian diet produced results as good in this respect, at least, as one containing meat.

On the other hand it is claimed that the metabolism of alcohol taken into the system shows that this substance is not stored up to form part of the normal reserves of the organism. It apparently disturbs the regular mechanism of nutrition tending to alter the method in which the proteins are utilized.

SUMMARY

To sum the matter up the study of the development of heat in the human body has resulted in the obtaining of valuable physiological information. From the theoretical point of view it has shown that the process of metabolism is regulated by thermochemical laws, and it thus verifies the well-known principle of the conservation of matter and of energy. From the practical point of view it furnishes precise data concerning the laws which control physiology, of the digestion, and assimilation of food and of the elimination of waste matter and thus furnishes a basis for the application of these laws to diet, in particular, and to general hygiene.

HOW FAST CAN BACTERIA TRAVEL?

WHEN one examines, by means of an ultramicroscope, bacteria of different kinds existing in the same medium, one is struck by the very remarkable difference in the rapidity with which they move. Many kinds move very slowly, others dart with agility hither and thither, while some glide across the field of observation with such velocity that their passage resembles the flight of an arrow. The average rapidity of motion of any given kind of bacteria has been approximately determined. Signor Sanarelli, the Director of the Hygienic Institute in Rome, continuing the experiments of other investigators in this field, has established the fact that the velocity of motion of the cholera vibrion in a 24-hour-old agar-agar culture carefully covered with guinea pig serum and kept at a temperature of 25° cent. is on an average 0.125 mm. per second, *i.e.*, 7.5 mm. per minute or 45 cm. per hour. This microbe travels much faster than any other observed by this scientist. A curious fact in regard to this is that the cholera vibrion possesses as a rule, only one cilium, while other microbes have a number of these organs of motion as a general thing. Evidently, therefore, the rapidity with which microbes move does not depend upon the number of cilia they possess, as would naturally be thought.

Spiders Used in Medicine*

Ancient and Modern Pharmaceutical Uses of the Spider and the Spider Web

By J. T. Lloyd, Ph.D.

THAT insects and their by-products, such as shellac and honey, play an important part in the economy of man, is known to all. Perhaps, however, it is better known to the physician than to the layman, that a few spiders play their rôle in the practice of medicine. These spider remedies, like the insect medicines, are not of modern origin. In old works one finds frequent references to cobweb, which was then administered in the form of pills instead of the modern alcoholic pharmaceutical preparation, Tela Araneæ.

In the popular mind there is often little knowledge of the distinctions between spiders and insects, although the class *Arachnida* (to which the spiders, but not the insects, belong) contains several orders, such as the scorpions, that are closer akin to the spiders than are the insects. Most of these are so distinct in superficial appearance that there is little probability of their being mistaken for spiders.

If one will remember that spiders have four pairs of legs, apparently no antennæ, and that their head is not separated from the thorax by a neck-like constriction, there need be no trouble to distinguish them from insects; which have three pairs of articulated legs, one pair of antennæ, and head and thorax separated by a distinct "neck." In the class Arachnida, spiders may be easily separated from other orders by remembering that thorax and abdomen are separated by a short, slender stalk, and the abdomen is not segmented. In their nearest relatives, the mites, the thorax and abdomen are fused and sack-like.

Since very early times many people have looked upon spiders with unfounded dread and superstition. During the medieval period, "Tarantism," a contagious disease that was common in Southern Europe, especially Italy, was believed to have been started by the bite of a spider. The victims of this disease were possessed with an uncontrollable desire to dance. In our own day and among our own people it is not unusual to blame the bite of a spider for swellings or itchings of unknown origin, but when questioned the sufferer is invariably unable to give other evidence that a spider is responsible for the trouble, than the usual answer, "What else could have done it?" On this negative evidence the blame is fixed for about 100 per cent of the "spider bites" of our people.

With the possible exception of a single species in our Southern States (*Lactrodectus mactans*, a jet-black spider with markings of yellow or red), and the true tarantulas of the South-West, it seems safe to accept that there are no spiders in our country whose bite need be in any way feared. The writer has handled large numbers of our native spiders, as well as (during excursions in the tropics) hundreds of the "banana tarantulas," which are not true tarantulas, but harmless spiders of a different family. True tarantulas may sometimes, however, be found in banana bunches. In no case has the writer been bitten, and frequent attempts to induce spiders to bite the tender skin between his fingers resulted in failure. Others who have made this experiment with success report that the wound inflicted is no more painful than a slight prick with a needle. That spiders do inject a virus into their victims is indisputable, but it is in quantities sufficient only to paralyze an insect. Besides, it is injected so slowly that little, if any, could be secreted during the short interval that the "jaws" remain in the wound of an animal as large as man.

Spider Web.—All species of spiders are capable of spinning web, though far from all spin orbs or sheet-like webs for entrapping prey. Many species only throw out a "drag line" as they move from place to place, or drop from surface to surface, and never spin a more complex web, except in wrapping their egg masses.

The web material, or silk, is produced in large glands within the spider's abdominal cavity. In the glands the material is liquid or mucilaginous, but (except certain parts of the viscid silk) immediately hardens on exposure to the air. From the gland it passes to the exterior through silk ducts, which often open on movable, finger-shaped "spinnerets."

In all, spiders produce seven distinct kinds of silk; some thread-like, some band-like, some viscid, some dry. Though most spiders secrete more than one kind of silk, and some spiders secrete several kinds, no one spider secretes all seven. Each kind of silk originates in its own distinct glands and passes to the exterior through its own opening.[1]

For pharmaceutical preparations an attempt is made to collect the sheet-like webs of *Coras medicinalis* (*Tegenaria medicinalis*) from the corners of rooms in warehouses and kindred places. It is probable, however, that the webs of the several species of dwelling-inhabiting spiders enter into all pharmaceutical preparations of web. No collector of webs could be expected to possess technical knowledge sufficient to enable him to distinguish species. If he should possess the required knowledge, it would be impracticable for him to take the time to apply his training for the examination of each web collected. Nor is there need for such discrimination. No reason why the web of one species of dwelling-inhabiting spider should be of different therapeutical qualities from another, has ever been recorded.

We do not know that a chemical analysis of spider web has ever been made. Tests given pharmaceutical preparations, however, show an absence of sugar, but give a slight reaction to Mayer's test for alkaloid. This is true also of tincture we have prepared from fresh web. The therapeutic value of the preparation may be in part due to this alkaloid.

In the present-day practice of medicine the large spiders of the sub-family *Aviculariinæ*, commonly known as "tarantulas," or "bird spiders," are employed by Homœopathic physicians. Under the name of *Mygale lasidora* the Pharmacopœia of the American Institute of Homœopathy, 1897, p. 408, gives directions for preparing the tincture of the "whole spider." Other references to the preparation and use of Mygale (tarantula) are given in Allen's "Encyclopedia of Pure Materia Medica," 1877, vol. vi., and elsewhere.

Spider and Spider Web in Medicine.—At least since the time of Pliny (first century A.D.) literature on medicine abounds in references to the use of spiders and their webs. The ideas of most of the old authors concerning the medicinal use of spiders, as may be noted in the following quotations, seem little more than "charm medicine" or superstition. Let us quote:

Spiders.—"The fly-catching spider, wrapt in a line cloth and hanged on the left arm, is good to drive away a Quotidian, saith *Trallianus* (sixth century, A.D.). But better if any of them be boiled with oil of bay to the consistence of a liniment; if you anoint the arteries of the wrists, the arms and temples before the fit, the fever abates and seldom comes again. *Koronides or Koranus* (King of Persia, who wrote a work on natural history). A spider bruised with a plaister and spread on a cloth and applied to the temples, cures a

*From *American Journal of Pharmacy*, Jan., 1921, and reprinted in *Chemical News*, April 8, 1921.

[1] A careful and interesting account, written in non-technical language, of the habits, anatomy, and classification of spiders, may be found in "The Spider Book," by John Henry Comstock: Doubleday, Page & Co., 1912.

tertian. *Dioscorides* (first or second century, A.D.). The spider called Lycos, put in a quill, and hanged on the breast doth the same. *Pliny* (first century, A.D.). That house spider that spins a thick fine and white web, shut up in a piece of leather or a nut-shell, and hanged to the arm or neck, is thought to drive away the fits of a quartane. *Dioscorides* saith he proved it to be true. Three living spiders put into oil, let them presently boil on the fire, drop some of that oil warm into the ear that is in pain, and it profits much. Or press out the juice of spiders with juice of roses, and put it in with wool. *Marcellus Empiricus* (380-408, A.D., or later). Pliny bids infuse them in vinegar or oil of roses and stamp them and then drop some into the ear with saffron, and it will still the pain certainly: Dioscorides affirms as much. *Sofratus* . . . saith, that Cranacolapsus (a certain spider) drowned in oil, is a present remedy against poisons, as the Scholiast of Nicander (second century, B.C.) professeth. Aetius (about 500 A.D.) for suffocation of the mothers, applied a cerate of spider to the navel, and said it did great good."

Spider Web.—"The spider's web is put into the unguent against Tetters, and applied to the swellings of the fundament, it consumes them without pain. *Marcellus Empiricus.* Pliny saith it cures runnings of the eyes, and laid on with oil, heals up wounds in the joints. Some rather use the ashes of the webs with Polonia and wine. Our chirurgians (surgeons) cure warts thus: They wrap a spider's ordinary web into the fashion of a ball, and laying it on the wart, they set it on fire, and so let it burn to ashes, by this means the wart is rooted out by the roots, and will never grow again. Marcellus Empiricus was wont to use the web of spiders found in the Cypress tree in a remedy for the Gout to ease the pains."—Mouffet, "The Theater of Insects," 1858, p. 1023.

A few of the early writers, like Antoninus Pius, and more during the medieval period, used the web to stop the flow of blood. For this purpose it was also used by the American Indians, as well as in domestic practice, no doubt with a real value. For example:

"Antoninus Pius (86-161, A.D.) was wont to say, that the quirks of sophistry were like to Spiders' Webs, that had a great deal of art and ingenuity in them, but very little profit. But how often hath the blood run forth from the body most miserably by a fresh wound? Yet it had been easy to have stopped it by laying on a spider's web."—Mouffet, "The Theater of Insects."

"*Telia Aranearum*, Cobweb. Everyone knows what this is, and how produced. It appears not in medicinal prescriptions, but as accident, for want of other helps, has taught its use to common people for stopping blood in a fresh wound. And this it seems to do by its extraordinary fineness; which makes it adhere to, and stop up the mouths of the vessels, so as to prevent the effusion of their contents."—Quincy's Compleat English Dispensatory, 1749.

"*Aranearum Telae Pharm. Edinb.*, Cobwebs.—These are applied by the common people for stopping the bleeding of wounds; which they effect, not by any styptic power, but by adhering to the part, and closing the orifices of the vessels."—Lewis' Materia Medica, London, 1768.

"The web astringes and conglutinates, and is, therefore, vulnerary; restrains bleedings, and prevents inflammation. The country people have a tradition, that a small quantity of spider's web, given about an hour before the fit of an ague, and repeated immediately before it, is effectual in curing troublesome, and sometimes obstinate distemper. This remedy is not confined to our own country, for I am well informed that the Indians about North Carolina have great dependence on this remedy for agues, to which they are much subject; and I am acquainted with a gentleman long resident in those parts, who assures me he was himself cured by it of that distemper. And, indeed, experience confirms the efficacy of this medicine in the cure of agues."—James, "New English Dispensatory," London, 1747.

In May, 1809, the *Medical and Physical Journal* of London published a long article by Dr. Robert Jackson, calling to the attention of the profession the medicinal use of spider web, or cobweb, in the treatment of intermitting fevers. Frequent references have been made to this article by subsequent publications in Europe and in America. After Dr. Jackson's publication, the use of spider web in the treatment of Malarial fevers seems to have been neglected until about 1865, when articles by Dr. L. M. Jones appeared in the *Lancet and Observer*, Cincinnati, and in Jones and Scudder's "Materia Medica." These again brought it to the attention of physicians:

"In asthma it is said to allay irritation, tranquilise the system, and act like a charm. In spasmodic complaints of females; in chronic hysteria, and other diseases attended with morbid irritability of the nervous system, it has been advantageously employed. Dr. Webster, of Boston, has found it beneficial in rheumatic affections of the head, asthma, and chronic coughs. He says it produces a pleasant delirium and exhilarating effects resembling the nitrous oxide gas. Dr. Gillespie used it in obstinate intermittents successfully, after other remedies had proved ineffectual. He thinks it more effectual than bark or arsenic.

"Dose.—Gr. v to vj, in pill; repeat every three or four hours. Dr. Jackson thinks a dose of gr. v produces nearly the same effects as one of gr. xx."—Jones and Scudder's "Materia Medica."

After the articles by Dr. Jones, the use of web gained constantly in the favor of many physicians. Present-day literature contains numerous testimonials to its use in the treatment of intermittent fever, and in diseases of sudden appearance, when there is a tendency to congestion, with cool clammy skin, cool extremities, and cold perspiration.

Among the patients of the late Dr. L. A. Perce, of Long Beach, California, were many tourists afflicted with malaria. Some of these had been, to use his words, "dosed with quinine until it had lost its effect." For such patients he states that he employed tincture of "Tela Araneæ."

Until comparatively recently, as already stated, the web was administered in the form of pills, instead of in the alcoholic pharmaceutical preparation, "Tela Araneæ," of today.

MOLTING IN SONG BIRDS

THE following remarks on molting habits of song birds were made by Dr. Stressmann of Munich at the meeting in Berlin on Oct. 10, 1920, of the German Ornithological Society in the Museum of Natural Science:

Among the small birds known as "*Schmätzer*" the *Oenanthe hispannica* and the *Saxicola rubicola* molt only once a year, while the *Oenanthe oenanthe* and the *Saxicola rubeara* do so twice a year. All of the Eurasian pipits molt semi-annually, whereas the neo-tropic varieties do so but once yearly.

The mock-nightingale, which lives in our latitude, molts not only in the fall, but in the winter also, in the zone of migration, but the birds which make their home in Corsica, on the other hand, do not molt in the winter. Among the buntings only the crested bunting (*Kappenammer*) and the ortolan, which are definitely migratory in habit, molt both in fall and in winter, while the other kinds which are stationary birds and birds of passage have only one yearly period of molting. The blue thrush molts once a year and the stone thrush twice. But the idea which might be deduced from these examples that the semi-yearly molt is peculiar to migratory birds is contradicted by the annual molt of the yellow-thrush and the swallow, as well as by the semi-annual molting of many stationary birds. A peculiar intermediate habit is found in the blue-throated warbler which molts merely the feathers of the throat when in its winter haunts in order to don its azure wedding garb. Many young birds molt their entire plumage, others lose only the small feathers, retaining those of wings and tail. Among the former are larks and swallows, etc., etc., while the latter include ravens, thrushes and the buntings except the gray bunting.

Flowers That Flash

So-Called "Electric" Flashes of Light Given Off by Certain Flowers

THE phenomenon of cold light is rather more familiar in the animal than in the vegetable kingdom, as in the well-known cases of the glow worm, the firefly, and certain tropical beetles, as well as a number of luminous fishes. However, there are numerous interesting cases of plants which are, likewise, luminous by night. The weird shine often seen in forests upon rotting wood is generally due to the common leaf fungus known as the *Hallimasch*. A similar fungus from Brazil, having the charming name of "Flor de Coco," gives off a pale green light by night, sufficiently strong to be used as a night lamp. In eastern Australia the *Panus incandescens* emits an emerald gleam and a similar glow is given forth by the *Tleurotus candescens*, the *Agaricus oleraceus* and *A. illuminans*, the *Polyporus noctilucens*, and many others. But while all these fungi give off more or less light in the dark, attempts to make use of them as night lamps are not very successful, since they soon die when removed from the wood upon which they feed and the preparation of artificial culture in which to grow them has so far not been found very practical.

But there is still another kind of luminosity in plants—we refer to the so-called electric flashes of light given off by certain flowers. This phenomenon was first described by Linnaeus' daughter, Elizabeth, in 1762, in blossoms of the Indian cress. But it is a matter of some dispute among the learned us to just what Elizabeth Linnaeus saw. A German professor, Dr. F. Thomas, published a monograph in 1914 upon the subject, setting forth his views that the so-called "phenomenon of Elizabeth Linnaeus" is identical with what is known as the Purkinje "phenomenon," but he was hotly taken to task by another learned gentleman, Mr. A. Schleiermacher in the *Biologisches Centralblatt* (Berlin), for January, 20, 1915, from whom we quote the following paragraphs:

"The Purkinje phenomenon is the name applied to the circumstance that objects which are red or orange in color when seen by twilight appear to be blue and green. It has been observed, however, that this phenomenon does not occur in the *Fovea centralis* (where only cones are found). When, therefore, some bits of orange-red paper or orange-red flowers are seen against a green or blue background, those which are seen in a straight line (whose image consequently falls upon the Fovea) appear to be brighter and more vivid in color than those which are viewed slantingly, and which appear to be of a dark reddish brown as detached against the comparatively brighter background. When the glance wanders from one of the orange-colored objects to another the latter becomes brighter since it is now the one in the line of direct vision. So long as the direction of the gaze remains unaltered, the object received by the *Fovea centralis* will remain bright, while the others appear to be dark. But this phenomenon could by no means be described as an appearance of lightning or 'flashing,' as the Swedish word employed by Elizabeth Linnaeus should, in my opinion, be translated.

"The phenomenon observed, described, and illustrated by me was utterly different—it was namely, a momentary side-wise brightening or whitening which appeared in some of the poppy blossoms, seen whenever the glance traveled rapidly and horizontally at a height of 20 to 40 cm. above the flowers, which were at a distance of about 2 meters. When the gaze was fixed upon any one of the flowers separately, the phenomenon ceased to appear. I was able to perceive the same phenomenon somewhat later upon observing by twilight an orange-red scrap of paper upon a blue background and convinced myself of the correctness of my first impression in spite of the fact that conditions were more unfavorable on account of its being winter time in the latter case. Moreover, I repeated the experiment last summer with colored scraps of paper with the same success—a success obtained likewise by many other persons, including far-sighted and near-sighted ones as well as those with normal eyes.

The interest roused by the description given by Elizabeth Linnaeus of the flashes of light or "lightning" she glimpsed proceeding from the vivid orange flowers of the Indian cress caused many other observers to watch for this phenomenon in these and other flowers, and similar observations have been reported as seen in fire lilies, helianthus, tropaeolum, tagetes and ringelblumen. The Swedish botanist, Fries, saw similar flashes from the flowers of the oriental poppy and the great Goethe himself, who was an ardent botanist, confirmed this, saying he had seen something flame-like flashing from the flowers; the poet even tried to explain the phenomenon by his theory of colors. According to a writer, Heinz Welten, writing in a recent number of *Ueber Land und Meer*, there have been many reports, too, of miraculous fires upon pines, ash trees, and Erlen, clinging to the buds and pointed leaves on warm summer nights.

Mr. Welten has the following explanation concerning this phenomenon to offer:

"All of these phenomena have their origin in the atmospheric electricity of which the air is full, especially before storms and which falls from the points of the leaves. It is even possible to occasion the phenomenon artificially, as when, for example, a specimen of the *Tropaeolum ma jus* or a begonia plant growing in a pot (the earth in which must be pretty dry) is placed upon an inverted tumbler or a lump of wax in order to insulate it, and the plant is then charged (in a dark room, of course) by means of an electrical machine. If the negative pole of the machine is connected with the earth in the flower pot and the positive pole is then brought near to the plant, small beads of light will appear upon the points of the leaves. But when the plant is positively charged, on the contrary, small plumes or feathers of light will stream from the leaf points. This experiment was first carried out on a large scale by the botanists, Molisch and Tubeuf . . . it affords a pretty novelty for an evening garden party.

"The phenomenon described is explained by the recent theory of duplicates of von Kries as a secondary image or 'ghost,' due to the primary excitation of the color-blind rods which sets in about 1/5 of a second later than the excitation of the cones. Because of the fact that there are no rods in the Fovea, this colorless (having a whitish gleam) after-image is observable only upon the periphery which corresponds precisely to my observation of the side-wise flash from the flowers. It thus becomes obvious that Dr. Thomas and I were really engaged in observing two entirely different phenomena."

Mr. Schleiermacher cannot resist the remark that he finds it very strange that neither Dr. Thomas nor his assistants were able to see the "secondary image" described above, adding that to his own knowledge many other persons had observed it and clearly described it, though they have received no previous information concerning it, thus precluding the idea that there might have been any psychological self-deception. He quotes a letter from a professor of physiology in Innsbrück in special support of his statement. He closes his article by describing the conditions under which this secondary image is most clearly seen, so that any of his readers may test for himself its reality and convince himself that it is entirely different from the Purkinje phenomenon with which he believes Dr. Thomas has confused it, in the following words:

"Upon a sheet of non-glossy paper, ultra-marine blue in color (the larger this sheet the better) lay a scrap of paper of any desired shape (square, round, etc.), orange-red in color and about 7 cm. long. An easy way of obtaining paper of the

proper color is to take an ordinary piece of filter paper and place it in an aqueous solution of flavein to which has been added a small amount of brilliant crocein. Then, look at the orange-colored piece of paper while standing at a distance of from 1 to 2 meters, the gaze being fixed at the upper edge of the large sheet of paper, *i.e.*, at a distance of 20 to 40 cm. above the orange-colored spot, the eye being moved rapidly along the sheet of paper. This repeats in all essentials the degree and color of a twilight sky when there are no clouds and at about ¼ to ½ hour after sunset, the degree of light being one that makes reading still possible without too great a strain on the eyes. If these directions be followed the secondary image will appear to move toward the red spot in the same direction as the motion of the eye. The luminous flash is frequently observed, even when there is a merely involuntary movement of the eye in the vicinity of the red spot, or upon the edge of the large sheet of blue paper; it is even sometimes seen when the sky is cloudy. A reddish evening twilight is, upon the contrary, unfavorable to the observation of the Purkinje, but the full brilliance of the flash is best observed when the sky is as clear as possible with a 'blue' luminosity. It is because these exceptionally favorable conditions so rarely occur in our land, in my opinion, that this effect of the lightning flashes from flowers against the background of foliage is so seldom observed.

In 1799 Goethe made an observation, the flower in question being likewise the perennial poppy, which practically agrees with my own . . . the only difference is that he describes the color of the secondary image not as whitish but rather as of the color complementary to orange—in his letter to Schiller he speaks of it as a very clear green.

"That the secondary image under certain conditions appears faintly colored, I have, myself, observed upon the color of Dr. Thomas, where it assumed a bluish tone against the more gray-blue background. This indicates that the sides, the colorless stimulus of the rods, there is a faint colored complementary subsequent image of the cones. The flashes are, indeed, observed most clearly upon a zone of the retina, wherein the colors are still very definitely separable and where, therefore, numerous cones are still present. In a sensation due purely to excitement of the rods, black scraps of paper ought to flash quite as well as the red (dark to the rods), provided they did not reflect more blue light. It is my observation, however, that the image is fainter when the black scraps of paper are used than in the case of those of a poppy red color. Another striking feature is, that with a *green* background the image is much fainter than with the blue one, although the most recent determination of the maximum of sensibility for the rods in green is about 515 milimicrons μ. . . . In higher latitudes than our own where in summer they rejoice in "white nights" favorable conditions of illumination appear to occur much oftener than in Germany; Fries, for example, was able to observe the "lightning flashes" during a period of a week and a half.

Phosphorescence

Existence of Solid Solutions in Light Stones

By T. A. Marchmay

THE word phosphorescence is somewhat loosely employed to signify the luminous rays given off by certain bodies unaccompanied by heat, and also certain other phenomena of luminiscence which are really quite different in character, such as the luminescence exhibited by selenium and certain other substances after exposure to sunlight or strong daylight. These latter phenomena are, of course, instances of borrowed light, and not of what is known as cold light, which is essentially a case of very slow combustion, with an ideal utilization of the calories of the substance consumed.

Every body must, as Walther Kuehn observes, writing in a recent number of *Umschau* (Frankfurt) be raised to a certain degree of temperature in order to emit rays of light, and a practical example of this fact is found in arc lights as well as electric bulbs and also in the mantel now in general use to increase the luminosity of gas flames. But men of science and, for that matter, the laity likewise, have long been familiar—certainly since the times of the Renaissance, with certain substances which emit rays of light of various color, according to the nature of their chemical composition. It is very recently, indeed, that scientists have been able to explain the cause of this baffling phenomenon, though it has aroused absorbed interest for centuries. The name phosphorescence was applied to this phenomenon because of the well-known fact that white phosphorus emits this sort of cold light at ordinary temperatures. It is now known that the production of this light in phosphorus is due to the action of oxygen, which slowly combines with it. If the phosphorus, however, be exposed to the air for even a comparatively short time, its temperature gradually rises until it reaches a point where it bursts spontaneously into flame, burning with great violence and brilliance. The writer has only too good reason to remember this fact, since she was severely burned upon one occasion while exhibiting a piece of phosphorus to a class in chemistry. One of the students touched the mass lightly with the point of her pencil, and even this slight amount of friction was enough to set the softly glowing mass off instantaneously.

The charming green gold light flashed by fireflies and glow worms is also due to a slow oxidation process, and here nature intervenes to prevent the combustion from ever becoming too rapid.

Let us first discuss, however, the first named sort of phosphorescense. Some quite remarkable discoveries concerning the nature and cause of this have been recently made, especially by the Heidelberg professor, Dr. Lenard. This authority first investigated the composition of the so-called artificial "light-stones," which were first prepared by entirely empirical methods about the beginning of the present century, and he discovered that they obey certain laws of quite surprising character.

To begin with, every light-stone must contain three components:

1. A sulphide of the earthy alkalies, *i.e.*, a compound of calcium, barium, or strontium, with sulphur.

2. A heavy metal which is present in extremely minute quantities in the form of a readily soluble salt; these include bismuth, manganese, nickel, copper, uranium, thallium, and platinum in especial.

3. A flux, such as salts of sodium and potassium, fluorspar, etc.

These three components bear an exceedingly simple relation to each other: the heavy metal exists in the form of a solid solution in the sulphide of the earthy alkali; when the molecules of the body exist in a state of fine division within a fluid, *e.g.*, as in the case of sugar and water, we speak of a *solution*, but in an exactly similar manner we may consider that we have a *solid solution* when one solid body exists in a state of fine division throughout the mass of another solid body. These relations have been explained and made particularly lucid by the work of Waentig. He produced light-stones with constantly increasing percentages of heavy metals;

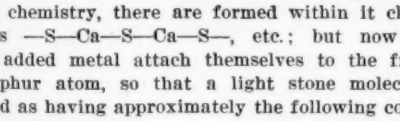
each of these was heated for periods of ten minutes and ninety minutes and the intensity of the light emitted by them was then examined. At 700° C. and with a longer period of heating there are first dissolved 4/80,000 and a saturated solution is formed; thereafter, a super-saturated solution is gradually formed; the sulphide has reached its maximum degree of capacity for absorbing the metal and in consequence of this particles of the metal begin to separate out upon the surface of the light-stone, the intensity of the latter being at the same time strongly diminished. At 800° C. and a period of heating ten minutes longer, the same phenomenon appears, but in a heating period of 90 minutes on the other hand, the curve rises abruptly, so that it would seem as if all of the metal added (*i.e.*, 16/80,000) is dissolved.

But here another factor makes its appearance, namely, the evaporation of the metal at a higher temperature, which thus practically cancels the disturbing influence of the separation out of particles of metal upon the surface. This was especially obvious in the curves for 900° and 1,000° C. In any case a comparison of the four curves for a heating period of 90 minutes shows that the most advantageous method of preparation is that at 800° C. at which temperature, too, Waentig secured the best results.

This theory of the existence of solid solutions in light-stones has recently received fresh support from experiments made by the Hamburg physicist Walter. He exposed a light-stone to intense light, a part of which was absorbed, while another portion was transmitted and again sent forth. By means of a complicated apparatus he succeeded in determining the amount of light transmitted, which, divided by the thickness of the surface of the light-stone, yielded the so-called transmission co-efficient; it was proved that these numbers have the same magnitudes that are found in ordinary solutions as, for example, in fluorescein in water, which furnishes a further proof of the dissolved condition of the substances.

But science has been concerned for a long time, not only with the composition of these bodies, but with the nature of the process, until finally Lenard, making use of the implements provided by the results of the modern atomistic theory and of theoretical physics, succeeded in explaining the essential character of the phenomenon. He first examined whether the intensity of the emitted light and the wave length of the exciting light are in any way related; pretty much all the practical light-stones were tested and the results represented in diagrammatic curves. Thus it was found that in a calcium sulphide having an addition of nickel, a spectroscope gave the following results: Besides the normal spectrum there appeared four clearly perceptible dark lines or bands, which occupy the positions of 635, 567, 527, and 440, 10^{-6} mm. wave length. It was proved to be true in all of the many cases, some of which were very complicated, that the wave length of the exciting light is always smaller than that of the excited light, or in other words: The curve representing the latter always lies behind that of the former and never coincides with it! This surprising law had been discovered by Stokes in fluorescing bodies, but was now found as we see, to hold good in phosphorescence.

In a later work thus Stokes' law finds itself supported, which fact, however, demands a more extended explanation. The emission of the light takes place from so-called centers of emission, and these are molecules possessing approximately the chemical formula $Ca_x\ Cu_y\ S_z$; according to the form of the carbon rings present which are extremely wide spread in organic chemistry, there are formed within it closed chains, such as —S—Ca—S—Ca—S—, etc.; but now the atoms of the added metal attach themselves to the free arms of the sulphur atom, so that a light stone molecule may be regarded as having approximately the following constitution:



From such a complex a ray of light falling upon it splits off an electron as the elementary quantum of electricity, which after a certain lapse of time, which depends upon conditions to be described later, returns to its point of emission in a vibratory movement. This "light electric" electron induces a sympathetic vibration in another electron, the "emission electron"—in other words, therefore, through the emission of a ray of light and a repetition of this process, the whole phenomenon comes to a standstill. As we see, the two kinds of electrons can be compared with two electric vibration circuits, such as are employed in wireless telegraphy, one of which excites the other to a sympathetic vibration by means of resonance. In any case the emission electron will send out light at the moment when its duration of vibration coincides with that of the light-electric electron; that of the latter becomes constantly less until it is finally smaller than that of the first—or, expressed in other words: The wave length of the exciting light is shorter than that of the excited light which constitutes a new proof for the above mentioned Stokes' law.

By means of the concepts thus developed we now find that it is also possible to explain the characteristic behavior of the light-stones at various temperatures. When a light-stone is first illuminated and then placed, for example, in liquid air or in a mixture of ether and carbon dioxide it is completely extinguished; but if it is now taken out of the freezing mixture it slowly emits a faint light, while if it is then heated in a Bunsen burner it suddenly begins to emit a very intense light, following which it entirely loses its capacity to emit light. Here, then, we have three different conditions to deal with:

1. The condition of cold, in which the electrons are split off without returning and the energy is in a measure stored up: the body emits no light.

2. The normal condition of durability, in which the electron slowly returns: the result is a quiet uniform emission of light.

3. The condition of heat in which the electron returns with great rapidity: in this case the light-stone emits an intense light until the vibrations have ceased.

Hence it must be essentially possible to incite the light-stone to artificial illumination of light, since the stored up energy must inevitably issue forth again without remainder, in which process, of course, a certain fraction is lost in the form of heat. Unfortunately, all light-stones thus far prepared lose their power so rapidly that we have not as yet succeeded in proving this in practise. Herein lies the problem of the most weighty importance: namely, the postponement so far as possible of the loss of power of the light-stone and the reduction of the capacity of absorption by means of the addition of a suitable flux.

RAPID DETERMINATION OF ALCOHOL PERCENTAGE.

A NOTE published in the *Annales de Chimie Analytique Le Genie Civil* (Paris), for Feb. 21, 1921, which quotes from the *Bulletin de l'Association des Chimistes de Sucrerie et de Distillerie*, gives a rapid method of determining the amount of alcohol in a given liquid. The process consists of treating a known quantity of alcoholic liquid placed in a glass tube graduated in tenths of a cubic centimeter with an excess of anhydrous potassium carbinate, and adding water thereto in case the percentage of alcohol is supposed to be greater than 90 per cent. After the mixture has been shaken or stirred thoroughly it is allowed to stand, whereupon it separates into three layers: a lower layer consisting of solid potassium carbonate; a middle layer consisting of an aqueous solution of potassium carbonate; and finally, an upper layer of alcohol and water, corresponding to the formula $4C_2H_5OH,H_2O$. The saturated aqueous solution of potassium carbonate which forms the middle layer contains 0.00275 volumes of hydrated alcohol per cubic centimeter. The composition of this hydrated alcohol has been definitely determined by means of a densimeter. The note contains the formula indicating the percentage of alcohol and gives the details of the operation.

Photographing Chemical Reactions

New Method of Recording Reactions Accompanied by a Variation of Pressure

At a recent meeting of the French Academy of Sciences (March 29, 1921), M. H. LeChatelier presented a note by M. Pierre Jolibois concerning a new method devised by him for recording chemical reactions accompanied by a variation of pressure. We present below an abstract of the process for whihch we are indebted to *Le Génie Civil* (Paris) for April 9, 1921:

The double galvanometer of M. M. LeChatelier and Saladin enables us to record by means of the camera the critical point of metallic alloys by passing through each of the respective galvanometers which compose the apparatus:

1. A current proportional to the temperature of the specimen;

2. A current proportional to the difference between the temperature of the specimen and that of a body which undergoes no transformation whatever during the period of time involved. M. Jolibois has sought to extend the use of this instrument and to adapt it to the study of certain chemical reactions. For this purpose he has devoted his attention to

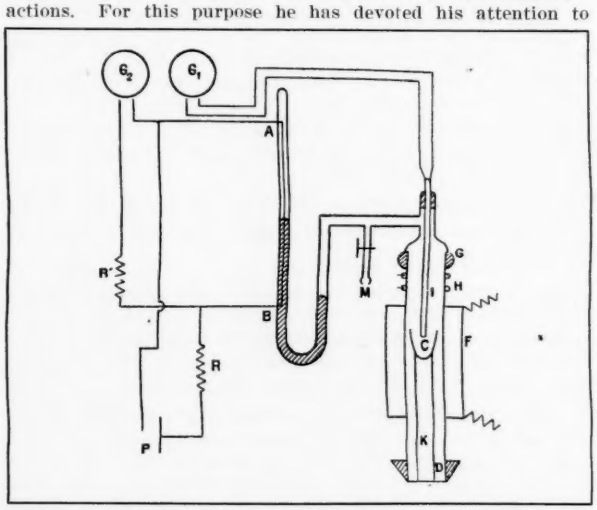


FIG. 1. DIAGRAMMATIC ARRANGEMENT OF APPARATUS FOR PHOTOGRAPHING CHEMICAL REACTIONS

those reactions which are effected with a liberation of gas producing a variation in the pressure.

The problem consisted in transforming a pressure into an electric current of an intensity adapted to set in action a galvanometer in order to obtain the curve which connects the temperature and the pressure. The author succeeded in doing this in the following manner:

The apparatus in which the reaction is performed communicates with the mercury manometer shown in Fig. 1. In the barometer leg A B of the latter a fine platinum wire is stretched, the wire being 50 cm. in length, about 0.1 mm. in diameter. Through this wire a current of electricity constantly passes, and the galvanometer which records the pressure is connected in parallel with the wire A and B. When the mercury rises in the leg A B the length of the wire traversed by the current is diminished, as likewise the intensity of the current in the galvanometer G_2. A simple calculation shows that the current is practically proportional to the length of the wire outside the mercury, when the resistance R and R' are large as compared to that of the wire.

The galvanometer which gives the temperature is graduated in the usual manner by recording the known fusing point and boiling point. The galvanometer G_2 has been graduated experimentally by measuring with a cathetometer the difference in level of the mercury and in causing a line to be described at the luminous point at a constant pressure and at a variable temperature.

The material to be studied is placed in a crucible C composed of some suitable substance. The crucible is held by means of a tube K in the center of a varnished porcelain tube heated electrically by a furnace F. To the upper part of the porcelain tube there is cemented a piece of glass G, through which passes a tube I made of transparent fused silica and designed to contain the thermoelectric couple.

The cement is cooled finally by a current of water H. The lower part of the tube is closed by a porcelain crucible D in the bottom of which are placed the absorbent reagents which serve to facilitate the study of the reaction (P_2O_5 in the case of the reduction of an oxide by hydrogen).

A lateral branch M enables the operator to procure a vacuum in the apparatus or to introduce the gases required for the experiment. This apparatus makes it possible to record in a single operation the tension of the vapor of a body and the dissociation tension of a compound. If a timepiece be added to interrupt periodically the luminous pencil of the double galvanometer the time will be inscribed upon the photographic records. In this manner it becomes possible to study the comparative rapidity of reactions and to measure, for any given rate of rise in temperature, the temperature at which any given reaction exhibits an appreciable rapidity (the reduction temperature by hydrogen, by carbonic oxide, reduction of oxides by carbon, etc.). Moreover, when several compounds are formed during a reaction the deviations in the curve enable the observer to predict the number of those in certain cases.

A still more general character can be imparted to this device. The author has constructed an apparatus which enables him to record the time upon one of the galvanometers by an analogous principle based upon the employment of a Mariotte's vase and a platinum wire whose useful electrical length is capable of variation.

RELATION BETWEEN BOILING POINT AND FUSION POINT

THE well-known French scientist, M. Maurice Prudhomme, has recently made known his discovery of the existence of two simple relations between the critical, absolute temperatures (T_c) of the boiling point under a pressure of one atmosphere (T_1) and the fusion point (T_f). Writing in the *Journ. de Chim. Phys.*, Vol. XVIII, No. 3, p. 307, Oct. 31, 1920, he states that the first relationship may be expressed in the following equation $T_c/T_1+T_f=C$, in which C is a constant for the groups of elements O and VII, the families of similar or analogous bodies, hydracids, halogen derivatives of the carbo-hydrates (methane, ethane, benzene) the chlorides of the metals in Group IV, chlorides of the metalloids in Group V, alcohols, ethers, organic acids, nitrates, etc.

The value of C varies but slightly from one series of bodies to another and differs from unity only by a few hundredths. In the case of certain bodies, H_2O, PH_3, CH_3Br, C_6H_5Cl, $CO(CH_3)_2$, C is equal to unity, and in this case $T_c=T_1+T_f$. The absolute critical temperature is equal to the sum of the absolute temperatures of the boiling point and the fusion point.

The second equation is as follows:

$T_f(T_c-T_f)/T_1(T_c-T_1)=C_1$, in which C_1 is a constant, like C, for the same series of bodies. The values of C_1 and C differ very slightly from each other: in certain cases, indeed, they are identical, in particular when $C_1=1$, since in this case $T_c=T_1T_f$.

By means of these two rules it is possible to calculate the critical temperature of metals with approximate precision.

The Universal Language

Ancient Musical Instruments and Modern Instruments Developed by Primitive Peoples

By H. A. Harges

MUSICAL sounds are commonly produced in one of three ways: by the vibration of one or more strings of gut, metal or some substitute therefor; by the movement of air columns in tubes or irregular shapes, and by the vibration of solid or hollow bodies of resonant material. While there are hundreds of types of musical instruments and thousands of variations, most of them fall naturally into the three "root classifications" given above. Take, for example, one of the simplest of musical instruments—the drum. We are apt to think of a drum as the ordinary bass drum, or kettle drum of the orchestra, while to the military man, the snare drum comes at once to mind. How few people know that there are other types of drum even in our midst to say nothing of those used by savage or semi-savage peoples.

Drums may be scientifically divided into three classes:

First: Single skin on some kind of a frame open at the bottom. Most savage drums are of this class and the tambourine of the Spanish dancer and the Salvation Army lassie are embraced in this classification.

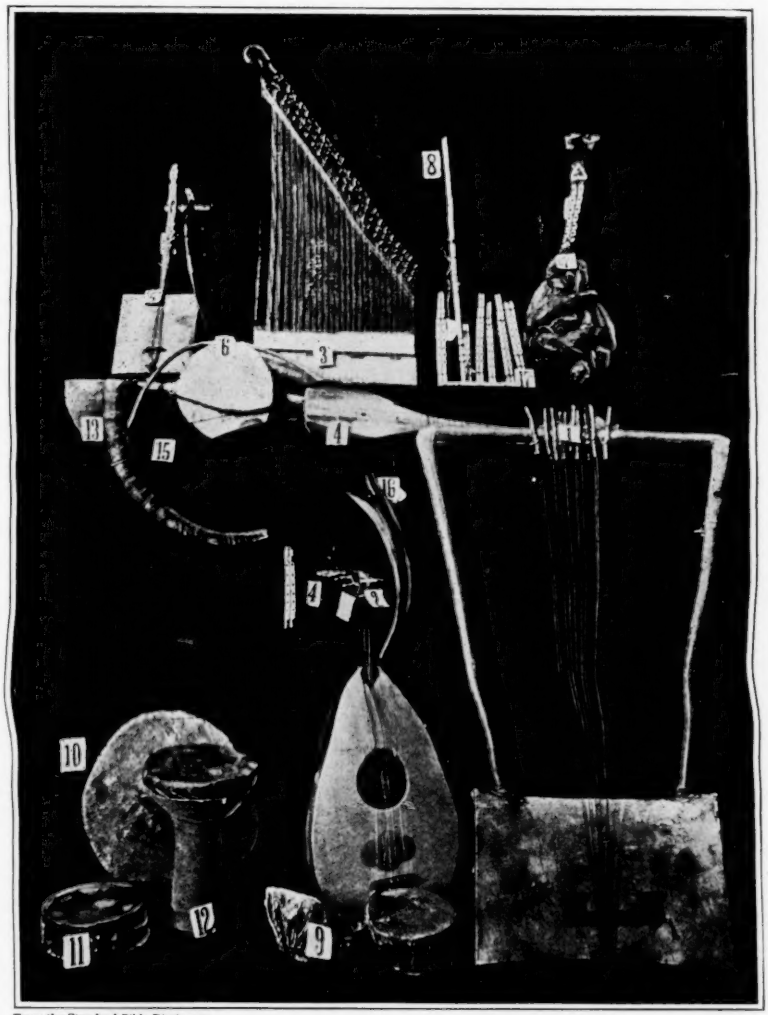
Second: Single skin on a closed vessel as a kettle drum. This instrument is about as unstable as a quicksand and the poor drummer of the orchestra must be constantly tightening up the stretchers somewhere. Instruments of percussion of this kind are found among those of many savage people.

Third: Two skins disposed at either end of a cylinder as in the child's drum and the military drums.

As a noise producer the drum has no equal and probably for this reason has been an especial favorite among primitive people and cymbals and gongs are close followers. It is probable that the earliest instruments were those of percussion, hence we have cited the drum as a typical instrument.

The earliest known instruments were probably suggested by the clapping of hands, stamping of feet, of which habits the human race have never divested themselves of. The resonance of hollow trees under the impact of blows probably also had its effect among the feeble tone-development of early peoples. The "bones" may be regarded as a very early instrument and originally they were four pieces of the ribs of oxen or horses. These in turn were followed by wind instruments which may have been suggested by the sighing of wind through standing reeds and bamboos. Such instruments were probably first used in the chase and finally for amusement. The human ear was, of course, uncultivated and it took a long time to recognize variations of pitch, tune and time. The cave-dwellers had stone gongs and bone flutes and we know from the wall paintings and sculpture, the Egyptians and Babylonians had brought such instruments to a reasonably satisfactory state of development. The Assyrians were a military people and their music, which was very military and strident, included trumpets, drums and the ancestor of the zither.

The Egyptians had schools of music and there were orchestras with a conductor! Stringed instruments predominated. The harp was the national instrument and we find it in all sizes from those carried in the hand to immense temple harps. Flutes and drums were also in use and we find pictures of a rattle or clapper which the Greeks also used in a more refined form. From all accounts the Hebrews were the best musicians, but the Children of Israel made no graven images and as the translation of the Bible in the time of James I. was made before the days of biblical archaeology we see Hebrew instruments as through a glass darkly. There is a very interesting exhibition of musical instruments of modern Palestine in the Case Memorial Library of the Hartford Theo-



From the Standard Bible Dictionary

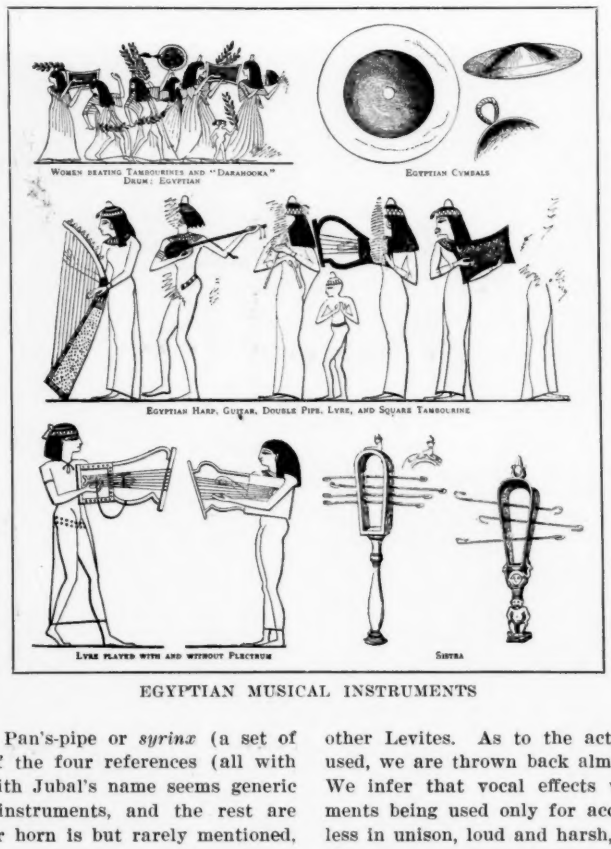
MUSICAL INSTRUMENTS FROM THE SUVIA DAVISON PATON COLLECTION IN HARTFORD THEOLOGICAL SEMINARY

1—*Kitâra* (Lyre); 2—*'Ûd* (Mandolin); 3—*Kanûn* (Zither); 4—*Tambûra* (Lute); 5 and 6—*Rabâib* (Fiddle); 7—*Arghûn* (Bagpipe); 8—*Shubâb* (Flute); 9—*Nakkara* (Kettle-drum); 10—*Daff Dervîs* (Dervish's Tambourine); 11—*Daff* (Tambourine); 12—*Derbekke* (Hand-drum); 13—*Nakkara* (Kettle-drum); 14—*Nây* (Flute); 15—*Shôfâr* (Jewish Ram's Horn); 16—*Bûk* (Horn); 17—*Nây* (Flute)

logical Seminary and the writer, through the courtesy of Prof. Thayer, was recently enabled to examine the collection in detail. The following description of musical instruments of the Bible is from the Standard Bible Dictionary (Funk & Wagnalls, and is republished by permission).

"The instruments named are representative of the natural groups that are observed everywhere: namely, those that are struck or shaken (percussive or pulsatile), those that are blown with the breath (flatile), and those with strings that are twanged. The Hebrews are not known to have had any form of viol—a stringed instrument played by the friction of a bow—though on this point our information may be defective.

"1. Of instruments struck or shaken there are four or five: (a) The tabret or timbrel, was probably a small bowl-shaped drum, or possibly a hoop-shaped tambourine. Of seventeen references, a decided majority are in connection with merry-making, and the rest religious, in the hands of the prophet-gild, or of worshippers. It appears usually with the harp, often with the psaltery or pipe, rarely with the cymbals or trumpets. (b) The cymbals were either hollowed metal cups held in the hands or little plates fastened to the fingers (castanets). All the ten or more references are in religious use, and all but one in the later histories. In one passage they are described as made of brass. They occur usually with the harp, psaltery, and trumpet, and with song. (c) Some pulsatile instrument (Revised Version *castanets*) which occurs only in the story of the upbringing of the Ark, was probably the Egyptian *sistrum* (a loop-shaped metal frame with loose, jingling rods). (d) Bells or jingles, as part of the trappings of horses, are once named.


Women beating Tambourines and "Darahooka" Drum: Egyptian
Egyptian Cymbals
Egyptian Harp, Guitar, Double Pipe, Lyre, and Square Tambourine
Lyre played with and without Plectrum
Sistra

EGYPTIAN MUSICAL INSTRUMENTS

"2. The flatile instruments represent both the flute and the trumpet classes. (a) The pipe was either a direct flute or flageolet, or possibly an oboe, doubtless made of cane or wood. Of the five references, one shows use by the prophet-gild and the rest are social. (b) Another pipe (*organ*, authorized version) is supposed to be some form of Pan's-pipe or *syrinx* (a set of graduated tubes of cane). Of the four references (all with mention of the harp), that with Jubal's name seems generic for all kinds of wood-wind instruments, and the rest are poetic. (c) The ram's horn or horn is but rarely mentioned, but was probably common as a rude instrument for signals and noisy demonstrations. (d) The curved trumpet, *shophar*, was probably derived from the foregoing, but possibly was often made of wood as well as of horn. The nearly forty references all concern the giving of signals, except some late ones. (e) The straight trumpet was probably always of metal. This is distinctly named over fifteen times, of which some refer to signalling, but in the later histories almost wholly in connection with the Temple ritual. It would seem that this in later times became the characteristic instrument of the priests.

"3. The stringed instruments are decidedly prominent, but their exact form is in doubt. (a) The harp was probably a lyre rather than a true harp, and therefore analogous to the modern Arab instrument. Over thirty-five references imply that this was universally employed in both secular and sacred connections. In two-thirds of these it is associated with the psaltery, in about one-third of them with the cymbals and the drum, and in about the same number with one or the other trumpet. (b) The psaltery was probably not a psaltery, which term properly belongs to one variety of the zither, but either a triangular harp, perhaps resembling the Greek *trigon* (as the early Christian Fathers understood), or, still better, some form of lute and therefore analogous to the common Egyptian *nefer*. In about twenty-five references it is nearly always associated with the harp, which would seem to imply that the two were not of the same class, but complementary. We are absolutely sure from monumental evidence (outside of Palestine) that the Hebrews used a lyre, though that this was actually called *kinnor* cannot be fully demonstrated.

"4. Collective terms for instruments occur in some cases, especially the expression 'implements of song.'

"It is likely that somewhat early in Hebrew history musicians were recognized as a distinct class in the community. Certainly this was true when the official ministrants of the Temple were fully organized. 'Singing men and singing women' are named as if well known, especially as helpers at festivities, probably also as professional mourners. Attached to the Temple, at least in later periods, were singers and players, both men and women, set apart from among the Levites. The Chronicler gives extensive details about their organization and activity. Their first institution is attributed to David, under the advice of Gad and Nathan, and they are said originally to have been divided into Kohathites, Asaphites, and Merarites. The total numbers is given as 288, arranged in twenty-four courses. In the Temple their station was at the east of the brazen altar; they served also on occasion with the army. At the Return the number of Asaphites is given as 128 or 148 and the total as 200 or 245. Provision was then carefully made for their free maintenance, as for the priests and other Levites. As to the actual styles and forms of music used, we are thrown back almost exclusively upon conjecture. We infer that vocal effects were those emphasized, instruments being used only for accompaniment. Song was doubtless in unison, loud and harsh, mostly in rather irregular cantillation or recitative, though sometimes strongly rhythmic, the melodies being based upon modes or scales differing from those of modern European music and very likely provided with manifold melodic embellishments, as in Oriental singing to-day. The parallelism of Hebrew poetry suggests that singing was to some extent antiphonal. From the instruments named, we infer that rude harmony was not impossible: certainly, there must have been crashes of concerted sound. It is a mooted question whether or not the traditional cantillation of modern synagogues sheds any light upon these ancient usages. This is improbable, or, if it does, there are no certain criteria for identifying the ancient material. That vociferous praise was made prominent in Hebrew worship after the Exile is evident; however, so far as we can now see, its historic significance lies, not in what it was artistically, but in the fact that its existence

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DANCE OF THE MOROS TO THE MUSIC OF CYMBALS AND HAND DRUMS

THE "MARIMBA" OR AFRICAN PIANO PROVIDED WITH RESONATING GOURDS

and the records of it have afforded a warrant for the free application of music in Christian worship."

The Hebrews and Greeks probably derived much of their knowledge of music from the Egyptians. In the time of King Solomon 4,000 musicians were employed in the temple service. Greek music is customarily divided into three periods —the Mythical Age prior to 675 B.C., the Classical Period 650-338 B.C., and the Alexandrian Period 325 B.C., to the Christian Era. The Greeks were so highly developed that they eschewed loud and blatant instruments of percussion, while string instruments, the lyre and cithara, were very popular and we all know of the Pan's pipes, or mouth organ of seven reeds bound together. The Romans adopted the Greek instruments, but trumpets and brass horns were added.

The secular and religious music of the early church and the music of the Middle Ages would lead us too far from the narrow path blazed out for this brief sketch, but what a fascinating vista is presented—the violin of the "string choir"; the "wood wind choir" with its flute, clarinet, oboe, and bassoon; the "brass choir" with its horns, trombones, cornets and trumpets, the organ, the oratorio and finally that most massive of all productions "Grand Opera."

Music has encircled the globe and we have gathered together a few examples of interesting instruments from widely differing climes.

The worst that has ever been said about the people of ancient Peru recently emanated from the American Museum of Natural History. It has been discovered that they had "jazz" bands. It is even hinted that the Inca host, in the siege of Cuzco, tried to rout Pizarro with the blare of oboes. The said reflection upon the character of the Peruvians is brought to light in a study made by Charles W. Mead, assistant curator of the department of anthropology, of the museum's collection of prehistoric musical instruments. They include bells, cymbals, rattles, pipes, flutes, whistles and an unmistakable ancestor of the oboe. No drums have been found in the old graves, but they were pictured by native artists of the time and described by early writers. "There is still used by a number of tribes in the Amazon region," says the museum's summary of Mr. Mead's findings, "a piece of cane from two to five feet long, with one end closed by some gummy substance, through which is passed a split quill forming a 'reed.' This is, of course, a forebear of the oboe. It was undoubtedly this type of instrument which constituted the 'cornets' said to have been used by the Inca army at the siege of Cuzco. The Incas are credited in Mr. Mead's paper with possessing percussion and wind instruments. They did not know how to make music by the vibration of strings, but really the only thing in their favor is their apparent ignorance of the saxophone.

Cymbals or metallic basins of varying sizes, set in vibration by clashing them together, are very old and were in use by the Assyrians. We find many references to them in the Bible and the modern Egyptians use cymbals that might have been picked off the walls. Turkey is still celebrated for its cymbals which are exported all over the world. Copper gongs and other instruments which stand high as sound producers are in use to-day in every savage and semi-civilized country of the world. One of our illustrations shows a Moro concert in the Philippines where cymbals, gongs and drums are used. The gong needs no description, but the drum is curious, for it is of the "keg" variety, and is beaten with the hand and fingers of one hand, while the other hand wields and beats the drum with sticks.

In Siam we find many interesting musical instruments, particularly the "Phan" or mouth organ, made of bamboo. There are sometimes as many as 14 pipes inserted in a hollow piece of wood and bound together with bamboo shorings. In an example at the Metropolitan Museum of Art, the longest pipe measures 70 inches.

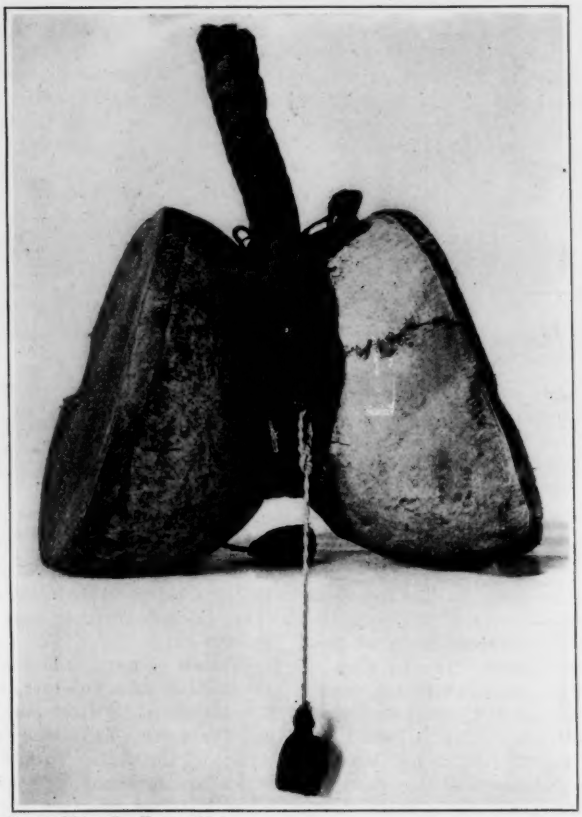
In India the Buddhist priest is a power in the community and the drum used is composed of skins stretched over two gourds or two skulls. Through the courtesy of Miss Frances Morris, Curator of Musical Instruments in the Metropolitan Museum, we are enabled to show a picture of a "Daman," or skull drum, which is 7¼ inches high by 6½ inches wide. The "raw material" for these skull drums is obtained from violators of the seventh commandment. The front part of the skull is cut away and the two skulls are fastened together and the cavities covered with skin, thus forming a drum with two heads. A cord with a bit of wax fastened to the end is attached at the junction of the two skulls and when the instrument is shaken the ball strikes the heads alternately. A bell is used in conjunction with the drum.

The Medicine Man of Siberia finds his drum and bone drumstick invaluable in overawing his native tribesmen. The Shaman's drum usually has a diameter of 27½ inches one way and 22 inches the other, and is 1¾ inches thick. Good examples exist in the American Museum of Natural History and in the Metropolitan Museum of Art.

The "Marimba" is an instrument which exists in many forms in many lands. The group shown in one of our engravings are dispensing music to an audience of Cameroons who have recently changed their allegiance from the Kaiser to France,

owing to circumstances beyond their control. The Marimba has been called the "African Piano" and it is certainly built along scientific lines, even though primitive. The instrument as shown in the photograph is supported by a harness and consists of bamboo slats which are tuned by making them longer or shorter, thicker or thinner. The slats are beaten with a stick of wood covered at the tip with virgin rubber. Under each of the slats is a resonator made of a dried gourd. Sometimes these resonators have a reed in the interior to help the volume of sound. A specimen from Zululand at the Metropolitan Museum has 12 bars, each about 2 feet 8 inches long. In certain districts the Marimba is used only by a special caste. In the catalogues of musical dealers today we find the identical principle used, only the bars are of steel and hard wood and the resonators are of brass.

The entire subject of musical instruments could be investigated indefinitely, but limitations of space prevent us from pursuing the subject further. However, those interested will find ample material for study in the museums cited, and a fascinating study it will prove.

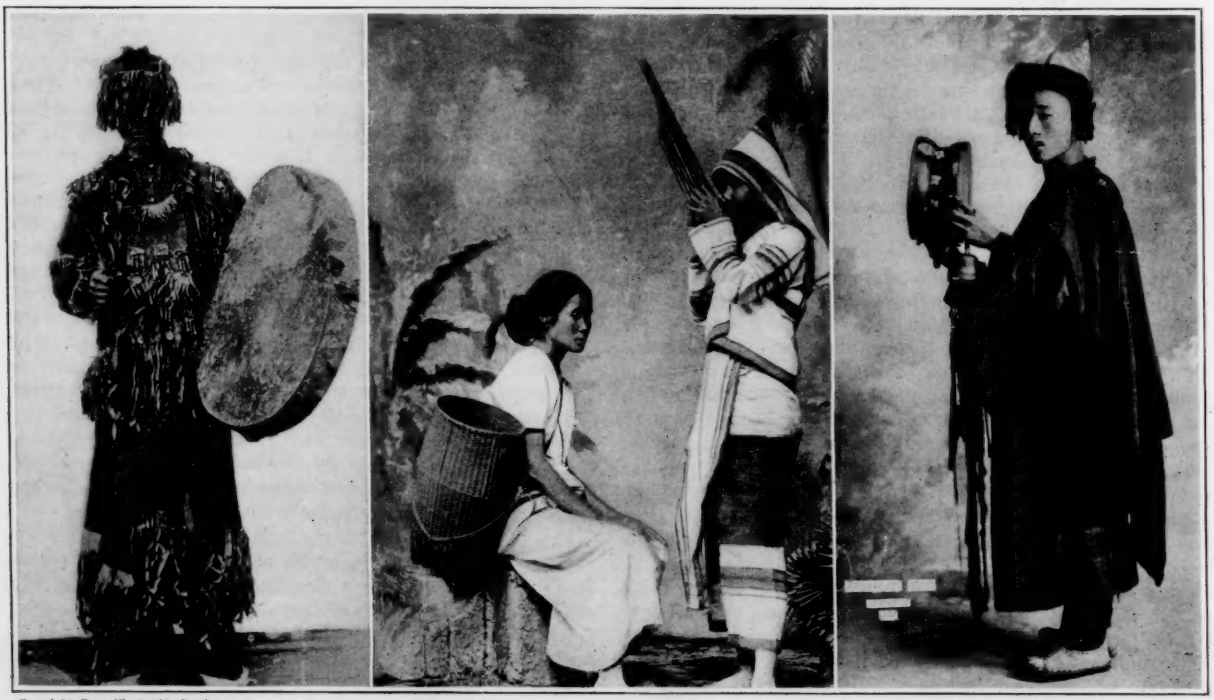


Courtesy, Metropolitan Museum of Art

THIBETAN DRUM OF THE SKULLS OF A MAN AND WOMAN WHO HAD VIOLATED THE SEVENTH COMMANDMENT

ACOUSTIC METHOD OF MEASURING AIR VELOCITIES

THE accurate perception of the direction of sound depends, according to Hombostel and Wertheimer, on the ability of the ear to appreciate the small time interval which elapses between the arrival of a sound-wave at the two ears. The perception of directions depends, according to a definite law, on the extent of this time interval. Now if the angle from which the sound is coming be known, it is easy to calculate the time interval, and in this way it has been found that time intervals of 3×10^{-5} sec. give a measurable effect. This method of measuring minute intervals is used by the author for the measurement of the velocity of a stream of gas or of a moving body, as follows: A sound wave is started from a point which is equidistant from two observers. Owing to the velocity of the intervening medium, it reaches them with a short time interval between the two stations. By angle measurement the value of this interval is deduced, and hence the velocity of the medium is found.—W. Kunze, in *Phys. Zeits.*, Aug. 15, 1920. Abstracted through *Science Abstracts*, April 30, 1921.



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THE SHAMAN'S DRUM IS THE SIBERIAN STANDARD OF MUSICAL INSTRUMENTS

THE MOUTH ORGAN OF SIAM. THIS INSTRUMENT MAY HAVE AS MANY AS 14 PIPES

BUDDHIST PRIEST OF INDIA WITH TEMPLE INSTRUMENT, DRUM AND BELL

More About Motion Pictures in Relief*

Another Theory Explaining the Optical Illusion of Projection in Three Dimensions

By Jean Brizon

IN an article recently published in *La Nature* (*a translation of this article appeared in the Scientific American Monthly of June*, 1921, *pages* 531-532.—EDITOR) Dr. Pech set forth his explanation of the optical sensation of "relief," *i.e.*, of an impression of three dimensions, obtained by him by means of a screen having a curved surface.

I have studied this question extensively for several years and I have obtained results which agree perfectly with the very interesting effects described by Dr. Pech. However, I explain these in an entirely different manner.

I was led to take an entirely different view of the matter by the results of the following experiment:

If two exactly similar positive views on glass, taken from the same negative, are superposed and then examined by transmitted light, the eye will have a tendency to bring forward the first view to the foreground, while relegating the second to the background, thus making a sort of natural selection. This impression is quite unmistakable, of which fact any

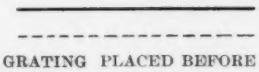


FIG. 1. A GRATING PLACED BEFORE THE SCREEN

one can readily convince himself by experiment; the eye receives an impression of depth in spite of the fact that the identical view is represented upon each of the two plates. The same thing holds true and the eye continues to make a selection, even when there is only a portion of the view upon the first plate, while the rest of the view is shown on the second plate. Those parts of the foreground borne by the first plate will attract those portions which are shown upon the second plate, and those portions of the background which are represented on the latter will be sufficient to throw to the rear the entire background, and this will hold good *no matter in what manner the image is distributed between the two plates.*

This result, which is not very interesting from a practical point of view, inspired in me nevertheless a lively hope that it might find an application in cinematography. I, therefore, projected views upon screens composed of several planes and I found that in all cases, no matter what the scene projected upon the screen, the eye at once made a selection so as to bring the first plane forward; in this manner a quite extraordinary sensation of streoscopic relief was obtained, a sensation which increased in intensity the greater the separation of the planes of the screen. The screen can be made in various manners; for example, we can place in front of an ordinary screen, at a certain distance from it, a screen in

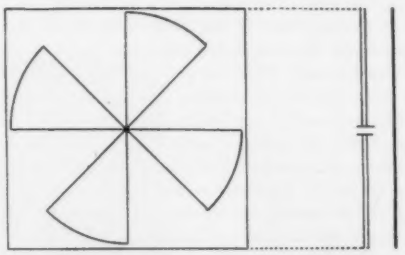
FIG. 2. A CORRUGATED SCREEN

the shape of a grill or grating formed of the elements of the screen (Fig. 1). We can also make use of a single screen having a series of grooves or corrugations as indicated in Fig. 2, which amounts in practice to the same thing as the former. Finally, a very amusing method of producing the screen may consist in making use of the well-known phenomenon of the persistence of vision upon the retina for a certain length of time; this third method enables us to give the spectator a complete and simultaneous view of the image upon several planes with spaces between them. This method consists in placing in front of an ordinary screen one or more portions of screens to which there has been imparted a rotary movement in a plane parallel to the fixed screen; in Fig. 3 a simple solution of this device is shown in which circular sectors are employed for the first screen.

Unfortunately, and the fact is greatly to be regretted, it is necessary in order to observe the screens, to be as far in front of the front screen as the distance between the extreme planes; this is clearly evident for when viewed from the side the image is in fact cut or deformed.

The screen employed by Dr. Pech offers a very happy method of obtaining a screen having several planes, since the edges alone of the screen are raised and this so slightly as not to discommode those spectators seated to one side; this curve has been so calculated, on the contrary, as to compensate at least in part for the error of lateral elongation which is the very one which annoys the spectator seated at one side when a plane screen is employed. This method, therefore, enables us to profit by a slight separation at the edges, in which location are often found the objects situated in the foreground. We thus obtain a slight impression of depth for these objects; unfortunately this impression can be proportional merely to the amount of the separation at the margins which is limited in practice.

I hope that Dr. Pech will not bear me a grudge since my object in saying this is purely scientific—but I am unable to



SIG. 3. THE ROTATING SCREEN

believe that the phenomenon of the distortion of the image upon the retina upon which he bases his theory, plays any part whatever in the case of the present screen. To my mind the proof of this is to be found in the mere fact that the same impression of depth or relief may exist at any rate so far as the spectator seated in the center is concerned, with a screen composed of hollows and protuberances arranged at random.

Besides, the well-known fact which Dr. Pech employs as the basis of his theory, namely, that a photograph observed either under a magnifying glass or from a very short distance, makes an impression of relief upon the eye, is in my opinion, due simply to the circumstance that in both cases the observer unconsciously assumes his eye to be in the same position as the lens by which the photograph was made, *i.e.*, subject to the conditions which are involved in perspective. In most cases, indeed, we always look at a photograph from a distance much greater than that of the focal length of the lens used in making the picture. But it is only in case one transports oneself in fancy into the same conditions as those under which the picture was taken, *i.e.*, when the eye represents the original lens, that one is able to observe the scene in its natural proportions; in other words, this is possible only when the relative magnitude of the planes is preserved.

In support of this theory I may state that I have made the observation that, so far as moving pictures are concerned,

*Translated for the *Scientific American Monthly* from *La Nature* (Paris), April 16, 1921.

the most definite impression of reality is obtained, when the ordinary screen is employed, by a spectator seated in the center of the room. The lens commonly used for taking pictures is, in fact, one having a focal length of 50 mm., and the degree of enlargement, which varies of course, according to the size of the room where the pictures are shown, is about 300 diam. for a 30 m. room. Hence those spectators seated at a distance corresponding to 300 x 0.05—*i.e.*, 15m. from the screen, are ideally placed to obtain the best results. Furthermore, attention may be called to the fact that when the spectator is too far off from the screen—*e.g.*, at the end of a very large room, the picture on the screen will look as if it were a painting.

The foregoing considerations appear to my mind to support a theory which may be stated as follows: The brain of man seeks always to recover the natural vision of the eye in the artificial images presented to it, and the sort of screen now in question merely lends its aid to this tendency.

In conclusion I may say that I believe it will not be very long before a method will be found—whether by making use of the principles I have just stated, or by means of others, of which it may be easier to make a practical application—to produce a true, but nonbinocular, impression of relief in moving pictures.

CURIOUS FACTS ABOUT EYES

IN the predecessors of the human race the eyes had a lateral position just as they still do in the human embryo. In the second month of embryonic life the eyes are still placed at the side and are slanting just as they still are in many dogs and cats; moreover, the eyes and nostrils of the embryo are still quite close together. The position of the eye is quite remarkable. In embryos from 2 to 5 months old are found all stages of the mutual coming near each other of the eyes, a deep furrow being formed above the nose which is still pressed somewhat downward. The forward direction in the position of the eyes is a great advantage. Animals with their eyes placed at the side of their heads find themselves awkwardly situated in regard to many objects. Sometimes it is very confusing to them to perceive a different image with each eye. This often makes it impossible for the animal to determine whether an object which seems large is actually large in fact or only appears so because of being so near, since when the eyes are placed at the side they lack the stereoscopic power of vision with the corresponding ability to judge correctly of magnitude and distance. Such vision is conceivable only when the visual axes of the eye are placed parallel to each other, when their voluntary steadiness of gaze is directed toward the same point. But the parallel position of the eye socket is not alone sufficient to procure parallel vision. In small children we see the eye wandering restlessly and aimlessly about as if they were seeking something. They do not arrive at a parallel placing of the visual axes until they are several months old, after constant practice.

The animals with eyes placed at the sides of the head do not possess a bony partition between the eye sockets and the space behind these which contains the muscles required in mastication. The boundary is formed by a thin layer of connective tissue. The narrowing of the nostrils through the frontal position and the approach toward each other of the eye sockets affects the organ of smell disadvantageously, and this is still truer in most apes, whose sense of smell is very feeble. The opinion was formerly held that the distance between the inner corners of the eyes varies considerably in various races of men, but this is not correct. There is but slight difference in this respect as regards different races; on the other hand, this feature varies widely among individuals within the same race. There are, however, fairly marked differences of race shown with respect to the form of the bony entrance to the eye socket. This is very long in Mongolians, Indians and Esquimaux while the smallest difference between the height and width of the eye socket is found in the nearly related Australian blacks, Tasmanians, and New Caledonians, as likewise in the Tierra del Fuegans in the extreme south of South America.

In all races the width of the eye socket is markedly greater in men than in women, but the difference is not so marked as respects the height of the eye socket, since this is but little greater in men than in women. In all branches of mankind the eye of the woman is less long than that of the man and another difference between the two consists in the fact that the female eye socket is much greater with respect to the magnitude of vision that is that of the male. It appears to be the fact that short-sightedness is much more commonly found where the entrance to the eye socket is long than where it is short. It is a very striking circumstance also that the breadth of the eye socket is in direct proportion to the shortness of the head. —Translated for the *Scientific American Monthly* from *Naturwissenschaftliche Umschau d. Chem.-Zt.* (Berlin) for Feb., 1921.

NEW MICROSCOPE FOR STUDYING OPAQUE CRYSTALS

VERY small opaque crystals are very hard to examine by present methods. The ordinary microscope, which is meant for use by transmitted light enables the operator to see merely their contour in case they are single and only a rather shapeless general contour when they form groups or clusters as is very frequently the case. For this reason some investigators prefer to make use merely of a very strong magnifying glass of sufficient power to reveal gleaming points from which they conclude that the body is crystalline in nature, although the form of the crystals cannot be seen in case they are very small. A great many devices have been proposed for examining and photographing opaque bodies and thin sections of alloys; it has remained, however, for a French inevntor, M. Maurice François, to suggest an improved method of examining opaque crystals. This was presented before the French Academy of Sciences at their session on April 18, 1921, but since it is too long for these pages we present merely a résumé of it, taken from *Le Génie Civil*, April 30, 1921:

M. François's process of observation makes it possible to perceive distinctly every facet and all the details of the crystals. It consists in observing by reflection crystals placed above an *opaque spot* and having their upper portion strongly illuminated by a very small concave mirror which is screwed to the lower portion of the objective, and which is pierced at its center by a circular aperture about 1 mm. in diameter.

In its complete form the system comprises three special parts, the concave mirror, the opaque spot, and the illumination which is situated in the axis of the microscope beneath the screw plate.

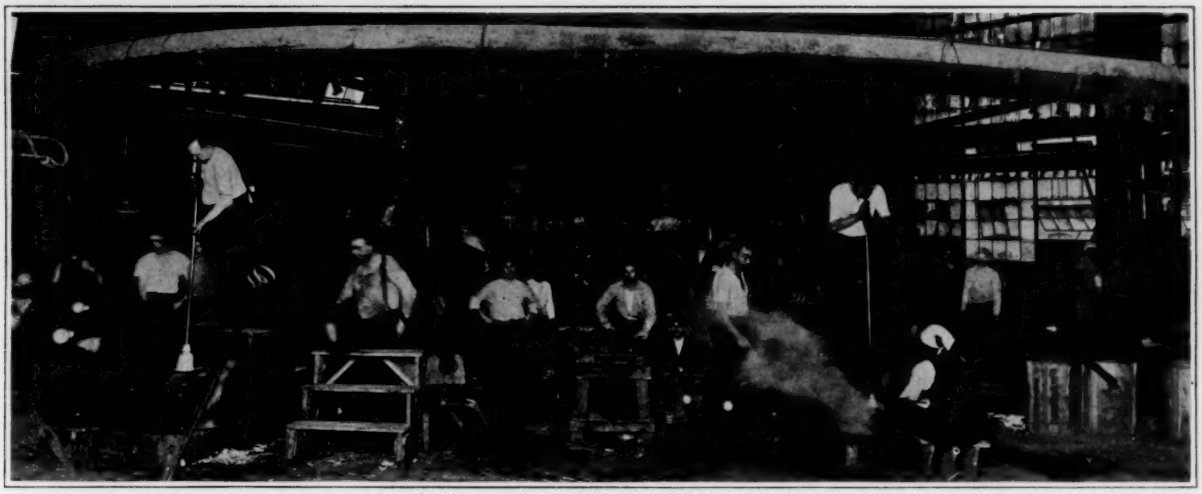
EFFECT OF HEAT ON CLAYS, KAOLINS AND BAUXITES

THE results of some interesting experiments with various clays made by the French chemist, A. Bigot, were recently laid before the French Academy of Sciences (Session of April 4, 1921). The experimenter found upon heating specimens of clay, kaolin, etc., to temperatures at which they soften, become deformed, and sag under their weight (these temperatures being regarded as practically fusion points), that the following laws obtain:

1. Bauxite, kaolins and clays which contain no free silica begin to contract below 1,000 deg. cent.

2. Any specimen of clay or bauxite which swells at a point below 1,000 deg. cent. contains free silica.

3. Clays and kaolins heated rapidly swell up before reaching the point of fusion. Bauxites do not exhibit such a swelling. This inflation is due to the volatilization of the silica or silicates, or of other acids or mineral salts which are set free at the instant when the substance becomes softened and vitrified; in the act of volatilizing, these elements form vesicles imprisoned in the mass, causing the latter to swell by the pressure they exert.



GENERAL VIEW OF THE POT FURNACE AND WORKING SPACE IN A PLANT DEVOTED TO THE HAND BLOWING OF GLASS LIGHTING FIXTURES, ETC.

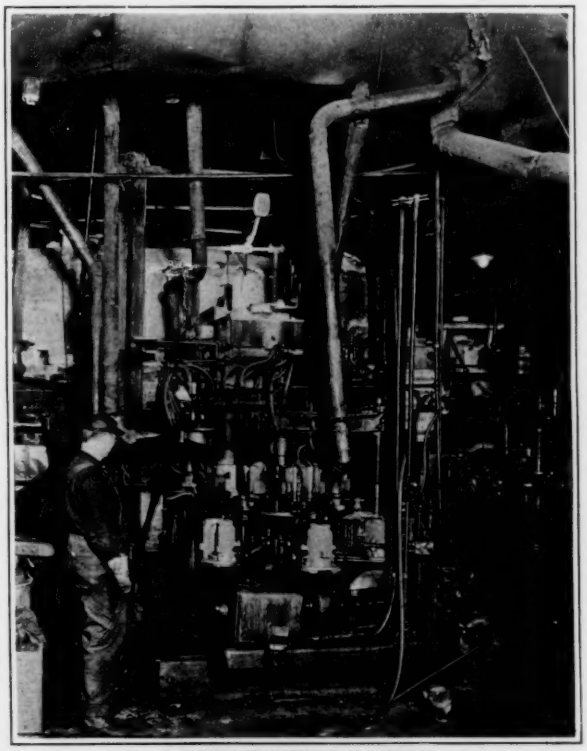
The American Glass Industry

Machinery Employed in Making Bottles, Window-Glass and Plate Glass

By Robert G. Skerrett

WHO has not wondered how glass is made? All of us are familiar with it, in one form or another, by daily contact, but not many of us know anything about the basic industry that has been a help to us for scores and scores of years. Indeed, it is doubtful if the laity at large has more than a hazy notion of the magnitude of this diversified trade which absorbs the attention of an army of 79,000 workers and executives.

According to the most recent authoritative figures available, the value of the glass commodities produced in this country in 1914 totaled $123,085,019.00; and at that time we had invested in the business capital aggregating $153,925,876.00. What is even more suggestive, perhaps, during the decade ending with 1914, the capital in the glass industry increased 72.2 per cent, and the value of the wares grew by nearly 55 per cent. The great bulk of these products supplied a domestic demand, and this fact illustrates how big a part glass plays in America's material life. While data are not at hand covering the entire industry for the past six years, still the manufacture of glass has expanded tremendously the while; and because of our enforced dependence upon our own resources during the World War, we have not only amplified our plant capacities, but we have proved that we can make various types of glass which previously we bought abroad.



A BOTTLE-MAKING MACHINE

The molds are mounted on two revolving tables—one above the other. On the upper table are the bottle blank molds in which the plastic glass is first formed, bottomside up, and then automatically turned over and delivered into larger molds on the table below where the bottles are blown and finished. The tank at the rear supplies molten glass in just the right quantity to the blank-forming molds as they revolve

The story of glass making in this country dates back to the beginning of the 17th century, and the records show that the English colonists erected a plant at Jamestown, Virginia, along about 1609. Those pioneers probably concerned themselves with the blowing of bottles. Twelve years later, a group of Italian craftsmen were induced to sail for Virginia, and their cunning was devoted to the fabrication of beads so much desired as a bartering medium in the settlers' dealings with the Indians. Gradually, the manufacture of glass of divers sorts was taken up by other of the American Colonies, and, as might be expected, interest for the most part was centered in providing bottles and window glass, needed alike by rich and poor.

For decades glass making in this country was confined to the settlements along the Atlantic coast, where was to be found sand in plenty, lime from oyster shells, potash from wood ashes, and an abundance of fuel in the prevalent stands of aboriginal timber. It was not until 1796 that coal was used to develop the necessary fusing or melt-

ing heat, and the first plant marking this departure was built at Pittsburgh. Generally speaking, the matter of fuel has since become one of the principal factors in determining where to undertake the manufacture of glass. This is not hard to understand when we recognize that the cost of fuel is, exclusive of labor, usually the largest single expense involved in the production of this commodity.

In the early days, wood and coal were severally employed for direct firing until Siemens, in Germany, brought out his regenerative glass furnace in 1861. He showed how it was possible to generate gas from the coal outside of the furnace and then burn it, on the principle of the Bunsen burner, in melting the glass ingredients held in clay pots. The gaseous fuel was more economical, reduced the melting time, and made it practicable to improve the quality of the glass while augmenting the output. As might be expected, the advent of natural gas and the use of fuel oil have influenced the industry and done much to stimulate the shifting of the plants to those points where these fuels could be had readily and at comparatively low prices.

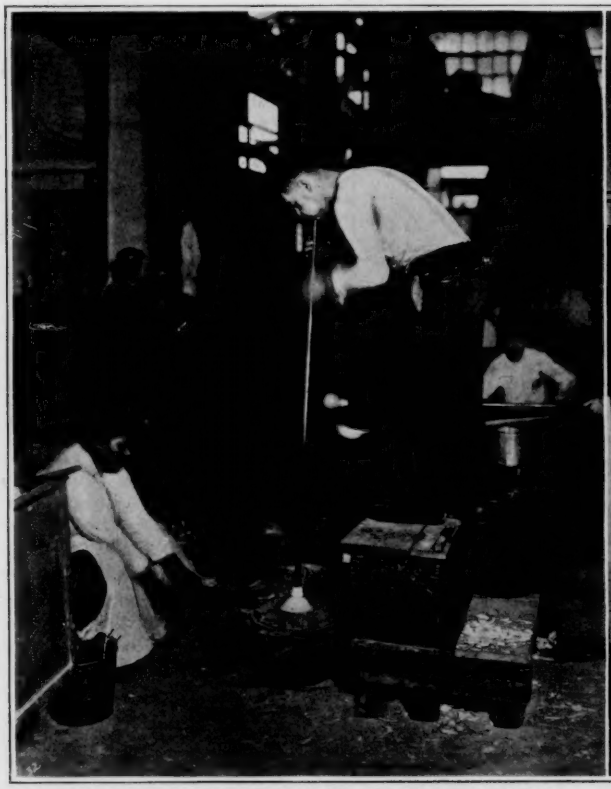
The idea of the regenerative furnace has been developed greatly since Siemens called it into being, and most of the furnaces installed to-day are of the so-called tank type which melt the glass in large quantities without recourse to pots; and they are so constructed that the glass, during its melting, undergoes automatically a purifying process. These furnaces run continuously for months at a time; they furnish glass of a superior quality, and they maintain a steady supply of many tons of the fluid, incandescent, vitreous matter.

In the past, the glass blower was an indispensable worker, and even to-day he continues to retain his place in the craft, but in diminishing numbers. The tendency now is to substitute machinery for manual labor wherever conditions warrant, and this movement is the consequence of the prime charge which wages represent in the total cost of manufacturing glass. It would be quite out of the question for us to have all of the bottles, jars, tumblers, etc., that we can now buy at a moderate price if inventive cunning had not called into being apparatus that require a minimum of human supervision. Some of these machines are semi-automatic and need the services of one or two men, while the most recent are entirely automatic and a single man can look after a group of them—his duty being merely to oil them or to remove a defective mold and substitute a new one.

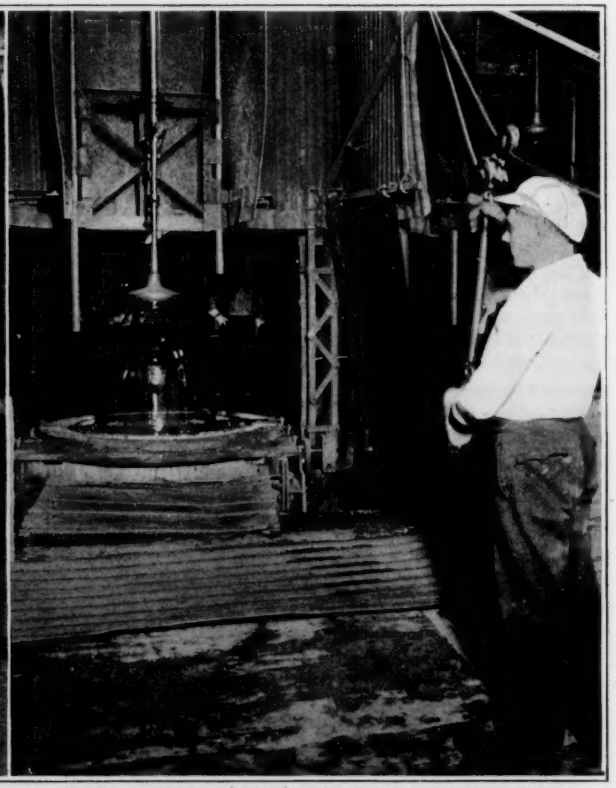
By means of exquisitely synchronized equipment, gobs of white-hot plastic glass are fed mechanically from the melting tank and sent scurrying down metal chutes into the molds of one, two, three, and more automatic machines, where the glass is successively formed into bottle blanks, for instance, and then delivered, without human aid, into the blowing molds where the bottles are finished. These apparatus are capable of turning out containers ranging all the way from 1-dram vials to 12-gallon bottles. The vials are produced at the rate of 165 a minute, and the bulky siphons are modeled at a speed varying from 10 to 14 a minute. The machines do this right along twenty-four hours a day for six days a week.

Instead of the lungs of the glass blower, motive energy is furnished in the form of compressed air, which is peculiarly fitted, because of its "cushioning effect," to do the pressing and blowing, to regulate the glass supply, and to cool the glass at certain stages. Further, compressed air tends to moderate the atmosphere where the men work, to give the necessary impulse to the gaseous fuel at the tanks, and to perform various other essential services. In the tumbler machines, air actuates the formative plungers and seals the molds so that the lump of glass can be confined and pressed into shape. As the newly-made tumbler issues from the mold it passes across the path of a stream of cooling air, and this makes the glowing vessel firm enough to hold its shape when lifted by pneumatically-operated tongs and swung onto a near-by rack or a metallic conveyor which transports it to the lehr or annealing oven.

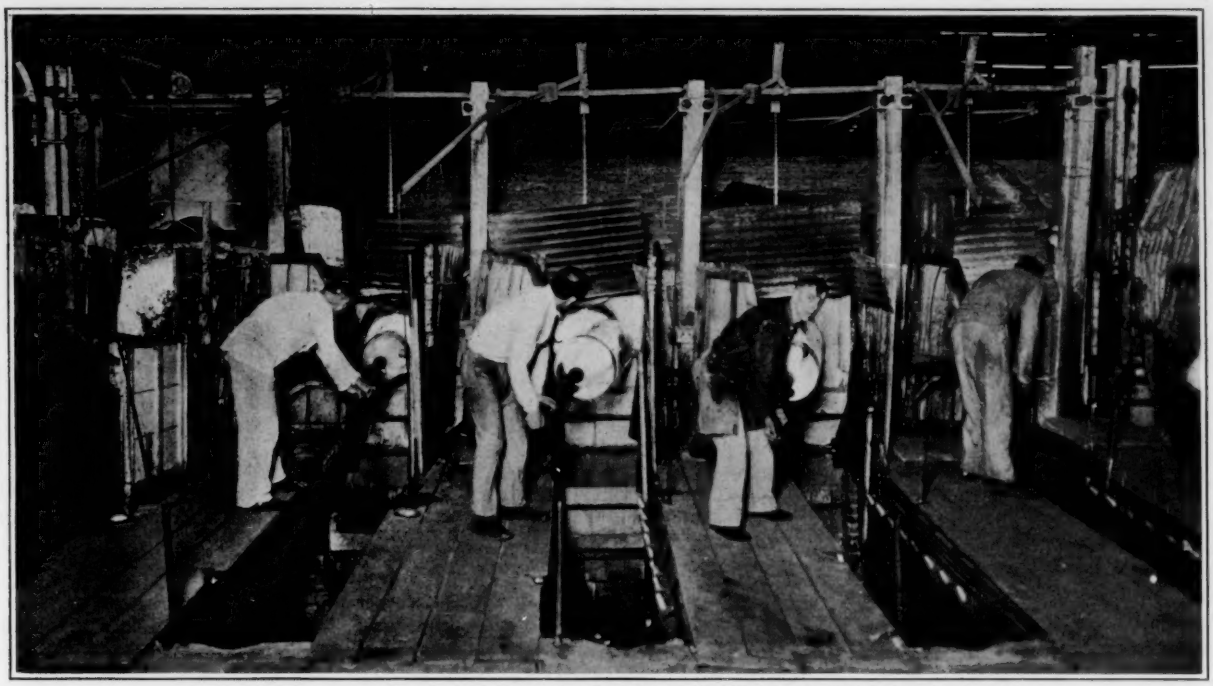
In 1914 our output of bottles, jars, and similar commodities



HAND BLOWER MAKING SHADES FOR ELECTRIC LIGHT FIXTURES



BLOWING WINDOW GLASS CYLINDERS BY COMPRESSED AIR



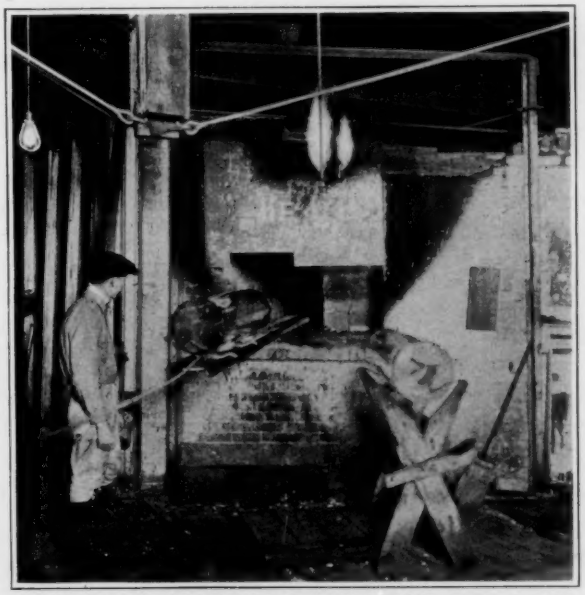
ONE SIDE OF A FURNACE WHERE CYLINDERS OF WINDOW GLASS ARE BLOWN BY HAND

The operatives are about to withdraw the partly formed cylinders from the furnace and to elongate them by swinging them in the adjacent pits or swing holes

was valued at $51,958,728; and this branch of the business represented something over 42 per cent of the value of the total glass production that year. The bottles, jars, vials, etc., manufactured in the United States four years ago aggregated 5,000,000,000. In 1900 our factories made only 1,121,000,000; and for years our export business was of moderate proportions. Three years back we exported containers to the value of $2,781,076, and during 1919 we sent to foreign markets wares of this kind worth $5,283,655.

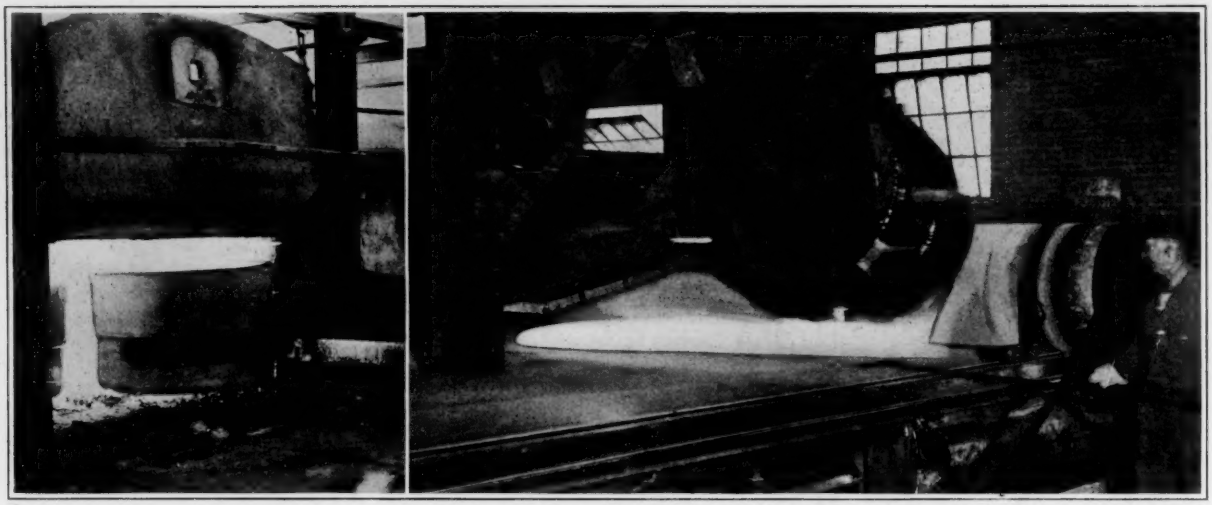
The machine-made commodity is superior to the hand-blown bottle because it is of uniform finish and of standard weight and capacity. The latter element is important inasmuch as it makes it possible, in turn, for the purchaser to employ automatic-filling apparatus—thus speeding up packing or charging. It is estimated that one automatic machine, capable of an output of 350 gross of beer bottles, for example, in twenty-four hours, takes the place of 54 skilled workmen; and an automatic feeder will deliver enough glass directly from the tank to the machines, where the commodity is milk bottles, to dispense with the services of 13 highly-trained operatives.

Without entering upon the niceties of the subject, it should be evident that in dealing with a material like glass it is necessary to handle it at every stage more or less carefully, and this is particularly so during the interval when it passes from the molten, viscous state to that of initial fixedness of form. It is indispensable that the glass be of just the right temperature when it leaves the furnace, and it must be given its impressed or blown shape while still plastic. Similarly, when it has been modeled and then "set" by a breath of air, no time should be lost in transferring it to the lehr. According to the article's condition when it goes into the annealing oven, more or less heat is required to bring it up to the desired temperature, so that the gradual cooling thereafter will cover a sufficient range to insure proper annealing. It is practicable to economize in fuel and to shorten the annealing period by a close coordination of the operations that take place between the machines and the lehrs, and thus to effect a saving of many thousands of dollars annually.



SHOVING A "ROLLER" OF WINDOW GLASS INTO A FURNACE FOR THE PURPOSE OF FLATTENING IT INTO A SHEET

In the building-glass department of the industry the manufacture of window glass dominates, representing about 48 per cent of the business. Building glass, by the way, includes plate glass, wire glass, and obscured glass, i.e., the material so often used for office partitions, doors, skylights, transoms, etc. During 1914, our plants produced 400,998,893 square feet of window glass, or more than 8,000,000 boxes, each containing 50 square feet, and having a value of $17,500,000. At that time, well-nigh all of it was for domestic consumption, and we sent abroad only about 1.8 per cent of the output. In 1917, however, we exported $3,483,596 worth of window glass, and we manufactured



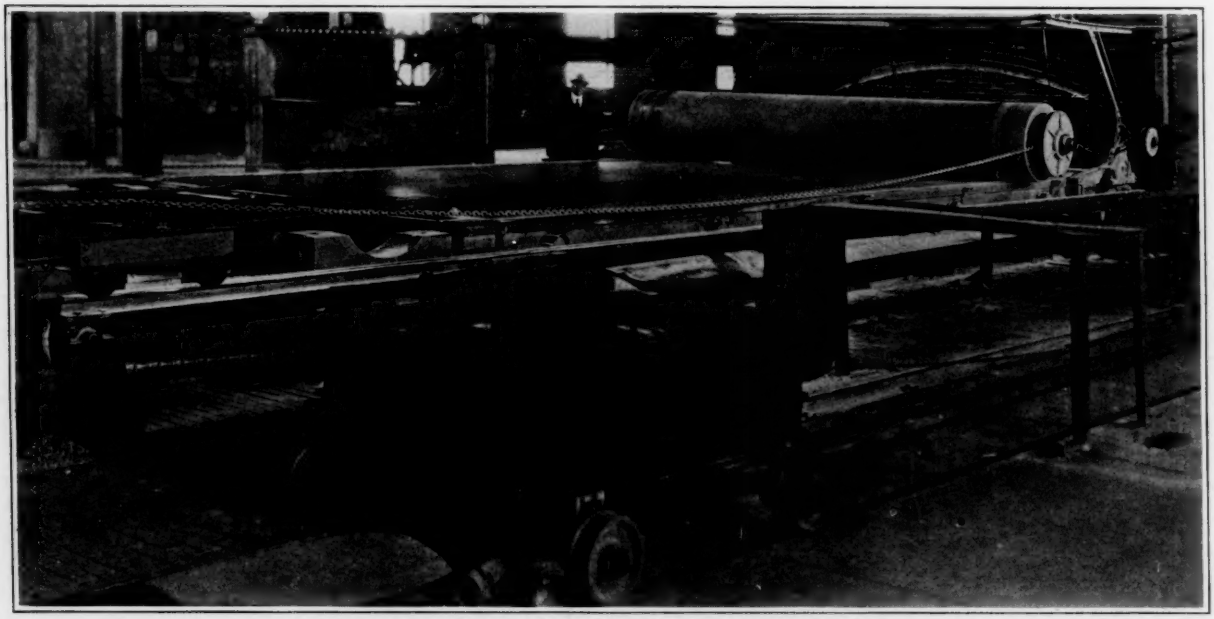
(*LEFT*) A POT OF MOLTEN GLASS BEING REMOVED FROM THE MELTING FURNACE AND (*RIGHT*) POURED OUT UPON AN IRON TABLE TO FORM A SHEET OF PLATE GLASS

9,000,000 fifty-foot boxes of the commodity. We could not have done this but for the machine processes which we have developed.

Approximately 60 per cent of all window glass made in the United States is of machine origin, and the 40 per cent remaining is hand blown. The difference between the two procedures starts after the glass is melted in any of the improved types of the tank furnace. However, the machines commonly use a softer glass, which is easier for them to deal with while they are forming cylinders or "rollers," which are much longer and larger than those possible where hand blowing is relied upon. In order that the layman may appreciate these competing industrial methods, it might be well to describe briefly how the hand blower does his work.

At a hand plant, cylinders are blown varying from 12 to 16 inches in diameter and 5 feet long, or they may be from 16 to 20 inches in diameter and 7½ feet long. A "shop," *i.e.*, a group of associated operatives, consists of three men—a gatherer, a snapper, and a blower. There are, besides, flatteners and cutters.

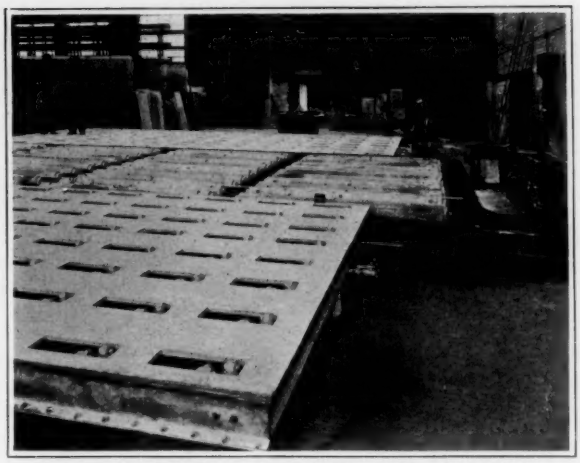
The gatherer puts his pipe into the tank and works it around to accumulate a lump of plastic glass of sufficient bulk. To do this he may go to the tank four or five times, and when he has the quantity desired for the blowing of a cylinder, then the snapper carries the pipe with its glowing load to the blower. The blower first manipulates the glass on an iron block to shape it properly on the neck of his pipe, and by the time this is done the glass has become too rigid to blow. Therefore, he takes it back to the furnace, reheats it, and then proceeds to blow and to stretch it out into a cylinder by swinging the mass back and forth in the swing hole alongside and beneath his platform. The cylinder is really modeled through the dual agencies of the blower's expanding breath, confined in the cylinder, and the glass's own weight.



THE CASTING TABLE OR "SLAB" OF A PLATE GLASS PLANT

After the glass has been poured upon the table the roller is moved from end to end to iron out the glass into a large sheet of uniform thickness

When the blower has finished his task, the snapper squares each end of the cylinder and splits it lengthwise on one side. Thereafter the glass is put in a furnace and pressed flat on "stones" of fire clay, and from this furnace it passes on through an annealing oven. Finally, it is cut into commercial sizes by the cutters, packed, and shipped broadcast. The hand window-glass blower produces an average of nine cylinders an hour, and his working week is one of forty hours. As a rule, he is not employed more than seven months a year; and the heat in which he labors is, broadly, the most debilitating factor with which he has to contend.



CUTTING TABLES IN A PLATE GLASS FACTORY

These tables are located at the exit of a lehr and are arranged with rollers to facilitate the sliding of the glass. The tables can be tilted so that the big sheets of glass can be caught on one edge and lifted off for stacking by means of a traveling crane.

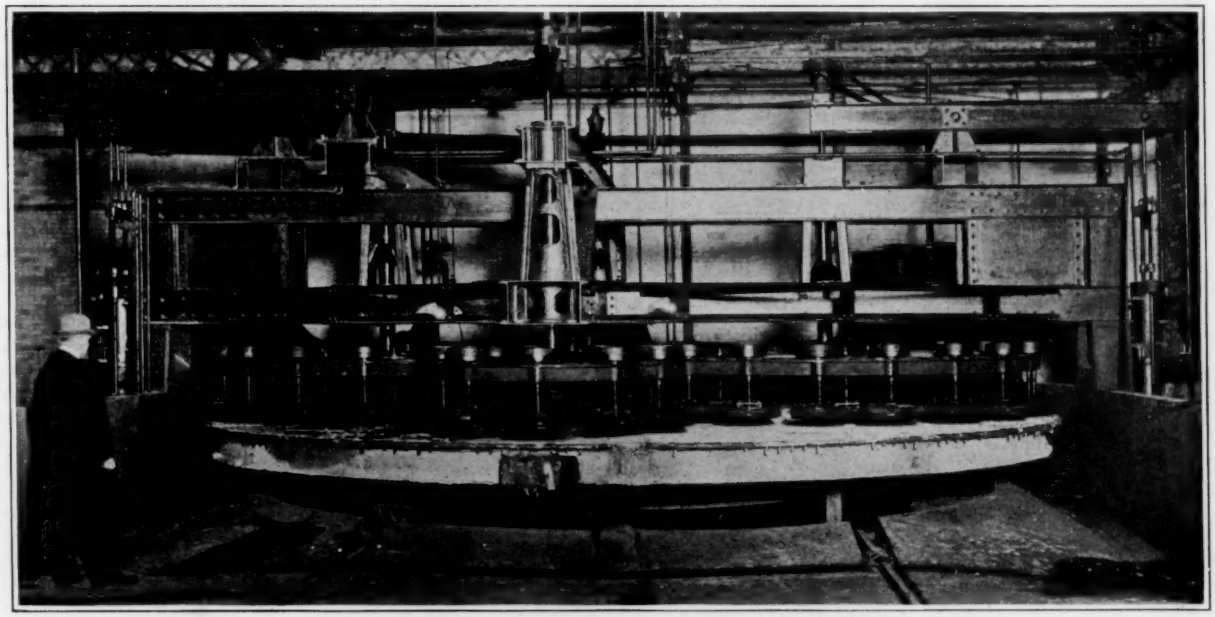
After prolonged experimenting, apparatus were brought out about 1902 that were capable of blowing successfully cylinders of window glass. Since then much has been done to improve these machines; and with them it is entirely practicable to blow cylinders from 20 to 30 inches in diameter and from 25 to 35 feet in length. That is to say, from a single cylinder so fashioned it is possible to obtain quite eight times as much glass as that yielded by a cylinder of the hand-blown sort. Not only that, but the large machine cylinder is formed faster. The blowing air is supplied by compressors, and a single operator can control simultaneously the functioning of from three to five machines.

In place of the hand-blower's pipe, the machine is equipped with a pipe terminating in a mushroom-shaped cup. This is mounted upon an electrically-operated hoist and guided so that it will move vertically without horizontal motion. This pipe is called a "bait," and is lowered either into a fire-clay pot, which is filled from the furnace, or into a projecting basin communicating directly with the great melting tank. In either case, the bait, as it is drawn out and upward, carries with it at the start a semi-globular bubble of glass which is linked with the surface of the molten mass. As the bait rises it pulls steadily after it a lengthening and solidifying cylinder of glass, and at the same time compressed air is fed into the growing cylinder to keep it expanded and to neutralize any collapsing force of the outlying atmosphere.

The problem of the hoist man is to regulate the vertical speed of the upbuilding cylinders and to control the while the distending charge of compressed air. There are attendants that look after the condition of the molten glass and that fill the pots where it is the practice not to get the glass right from the furnace. Again, there are other operatives whose duty it is to correct defects in the forming cylinders which, if not dealt with promptly, might cause the cylinders to burst and to occasion a loss of valuable material. One has to see these machines at work to realize the ingenuity that has been devoted to their development. It seems a violation of natural laws for the molten glass to flow upward as the cylinder rises out of the bath, but this apparent paradox is due to the viscous nature of the glass and to the quickness with which it "sets" when its temperature falls below the melting point.

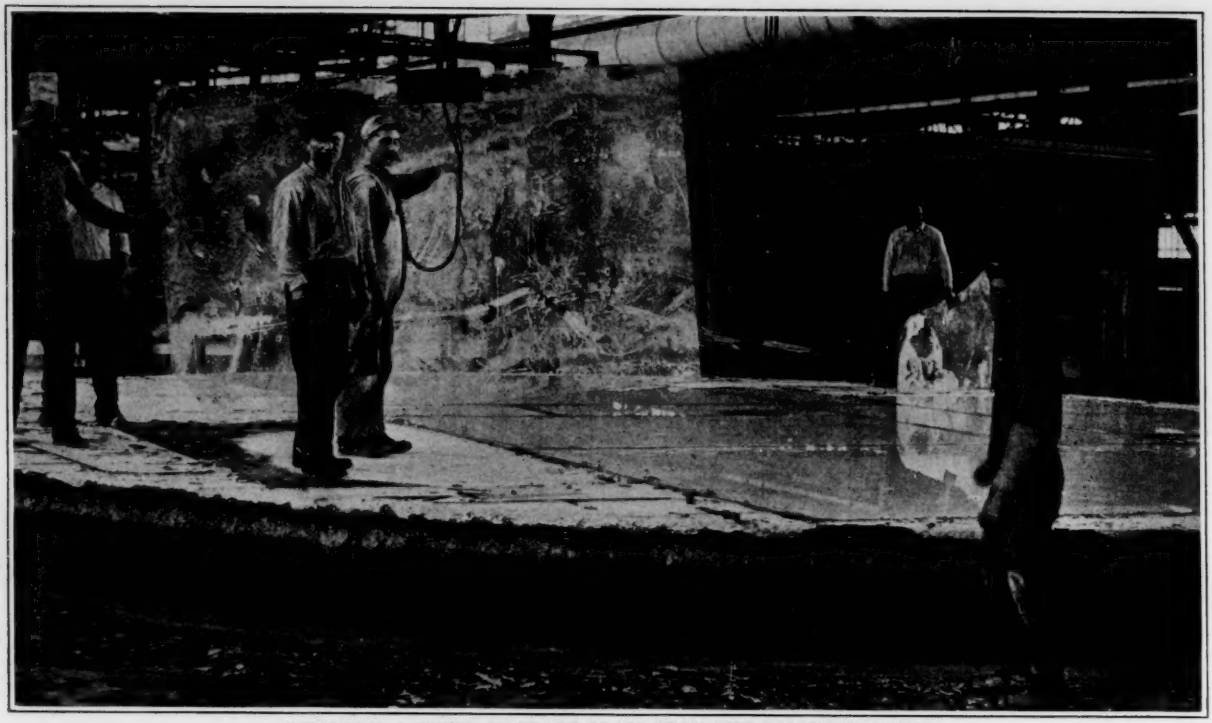
But there is still another and later method by which window glass can be made by machine. This process draws a continuous sheet of glass, and does not make cylinders which have to be split and flattened.

The sheet-drawing system requires even less labor than that for the mechanical blowing of long cylinders, and is the outcome of an invention originating about thirteen years ago. Many technical difficulties had to be overcome, and one by one



THE POLISHING MACHINE OF A PLATE GLASS PLANT

The circular table is mounted upon trucks so that the glass can be carried first under the grinding machine and then to the polisher



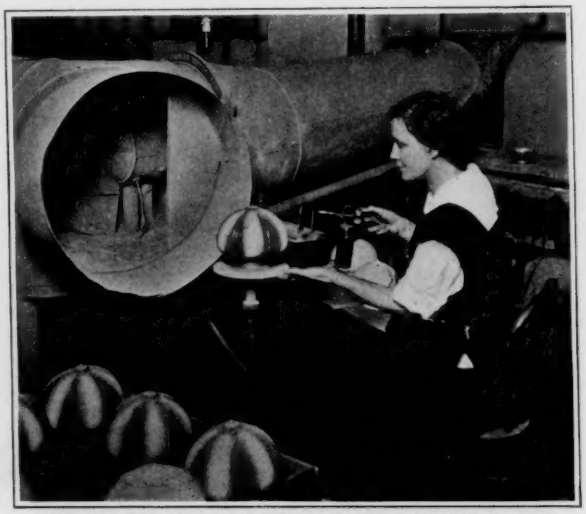
REMOVING A SHEET OF PLATE GLASS FROM THE POLISHING TABLE

these have been mastered until it is practicable to draw continuously a sheet of glass 200 feet long and 5 feet wide. Depending upon the thickness of the glass the sheet grows at the rate of from 2 feet to 8 feet in length each minute, and the thickness of the sheet can be varied from 1/24-inch to ¼ inch.

To start the formation of a sheet, an iron bar, the bait, about 5 feet long, is lowered, in a horizontal position, into the tank basin filled with molten glass. Next, the bait is lifted and it pulls up with it a clinging strip of plastic, glowing glass. After ascending for a distance of 2½ feet, the bait passes over a roll and travels horizontally, at right angles, to its former course, drawing the lengthening sheet of glass after it and into the contiguous lehr. Just before entering the lehr, however, the glass moves along on a flattening table; and when the bait has cleared this feature of the installation, it is broken off and hoisted out through the top of the oven, while the glass remaining in the annealing furnace is gripped and carried forward mechanically by a series of power-driven rollers. After a run of 200 feet, the glass reaches the cutting table, at the far end of the lehr, and there is subdivided into sheets 208 inches long. These are afterward cut into various commercial sizes.

In the manufacture of plate glass, the molten material, in big pots, is removed from the melting furnace and poured out upon great iron tables edged by a frame of a height suitable to the thickness of the sheet to be cast. Immediately after the glass is teemed from the pot, a heavy roller, which spans the table, flattens out the glass and presses it into the desired form and thickness. The sheet so made, when sufficiently rigid, is lifted and shifted laterally and then shoved into the first of a series of annealing chambers. When it has passed successively through these several compartments —with their lowering temperatures, the annealed sheet issues upon a tilting table, actuated by compressed air, where the glass is cut into large sheets. At this stage the surfaces of the glass are rough. The next step is to polish them.

The polishing tables are big revolving metal discs upon which a number of sheets of glass are secured by a binder of cement. Supported by a framework above each table are numerous smaller discs or pads, and these are mounted so that they can be brought into contact with the glass. In the first operation the pads grind away the roughened upper surface of the glass—sand and emery being consecutively used for the purpose. With the grinding done, the table, which is equipped with trucks, is wheeled beneath a polishing machine, where the pads rub the upturned surface with rouge. The two treatments consume something like three hours. With this work completed, the sheets of glass are reversed, so that the nether rough faces may be ground down and polished. When the glass is finished the sheet is only about half as thick as it was originally. In 1914 we produced more than 60,000,000 square feet of polished plate glass which was valued at nearly $15,000,000, while in 1917 the output reached 75,000,000 square feet.



TINTING ELECTRIC LIGHT SHADES BY MEANS OF THE AIR BRUSH

Mention has already been made of those departments of

the blown and pressed glassware industry having to do with the machine production of bottles, jars, tumblers, etc. The finer commodities, however, are hand blown, and such is the case in the making of lighting goods, pitchers, goblets, vases, and divers other articles. In the so-called "off-hand process," where the craftsman does his own blowing, the glass worker gathers a small ball of glass on the end of his pipe by dipping it in the molten mass and then quickly rotating and withdrawing it. He then rolls his "gather" on a polished iron plate, causing it to assume a cylindrical shape. Then, by a combination of blowing and swinging, the glass bubble is elongated and distended, after which it is put into a hinged mold. With the mold closed, the artisan continues to blow so as to force the plastic glass outward and well into every part of the mold, and in that way he gives it the desired form.

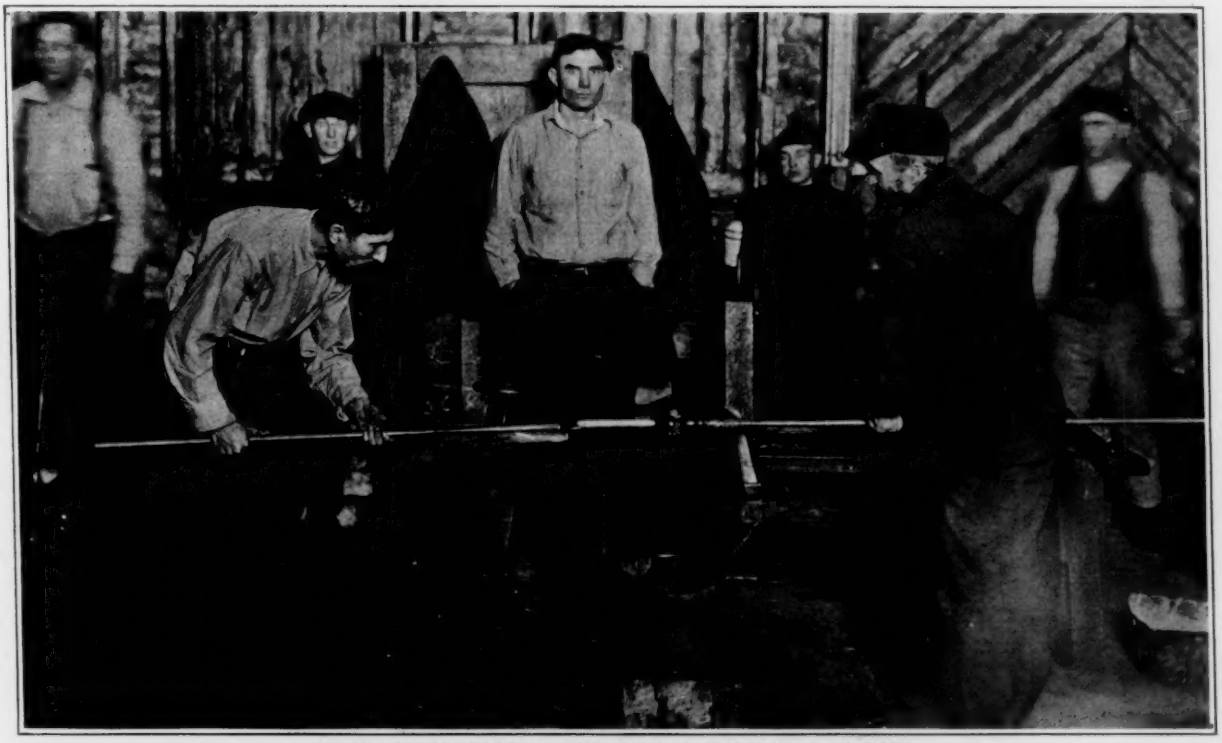
FINISHING UP A HAND-BLOWN PITCHER

The worker is engaged in attaching and modeling the handle from a lump of red-hot plastic glass

When the ware is to have a high polish, and it is so modeled that the glass body can be rotated within the mold while still incandescent, what is known as the pasting process is employed. That is to say, the inner surface of the mold is covered with a layer of paste and dusted with fine charcoal or powdered cork. A glass blank blown in the mold serves to carbonize the paste; and this graphitic deposit thereafter, in contact with the rotated and forming article, imparts to the latter a characteristically brilliant finish. In the making of vases, pitchers, wine glasses and goblets much work is done upon them after they come from the press or the primary mold, and the artisans show a great deal of skill and cunning in the execution of these concluding touches. Inasmuch as the glass chills and solidifies quickly, the commodity in the making has to be reheated one or more times. This is done in a small furnace located near by and popularly known as the "glory hole."

The production of pressed and blown ware, which includes a wide variety of articles, was valued in 1914 at $30,280,000. The output was an increase of substantially 38 per cent over that of 1904, and represented well-nigh 25 per cent of all kinds of glass manufactured seven years ago. It is not possible to say just how much blown and pressed ware we turned out in 1917, but in the course of three years our exports grew from $2,671,000 to $5,412,000 in worth.

In the matter of optical glass we have made ourselves independent of Europe, and today American glass of well-nigh every kind equals the best of the competing foreign products.



THE PRIMARY STAGE IN THE HAND BLOWING OF A PITCHER

The bowl has been formed and is about to be broken off from the blow pipe so that it may be reheated to facilitate the modeling of the spout

PROCEDURE CHART FOR THE REMOVAL OF STAINS FROM WASH GOODS

KIND OF STAIN	COTTON	LINEN	WOOL	SILK	COLORED GARMENTS
ALBUMIN.	Removed in the standard washing process.				The methods recommended for white goods are equally effective for colored goods, PROVIDED THAT THE REAGENTS USED HAVE NO EFFECT ON THE COLOR OF THE MATERIAL. Tests should always be made on some hidden portion of the garment before the reagent is applied to the stain. Begin with the simplest method and work up to the more complex and drastic procedures.
BLOOD.	Removed in the standard washing process. The stain of the hemoglobin will be removed in the bleach bath.		Removed in the standard washing process. The stain of hemoglobin may be removed with hydrogen dioxide solution.		
BLUEING: ULTRAMARINE.	Removed in the standard washing process. If this does not remove all of the spots and specks, treatment with "sour" will decompose them.				
PRUSSIAN.	Before coming into contact with an alkali, these stains will wash out in clear water. If contact with an alkali has changed the spots to ferric oxide (iron rust), a mixture of acetic and oxalic acids (see Chart No. 1, "L. N. A. Standard Formulas") must be used.				
ANILINE.	Many of the aniline blue stains will be removed by the standard washing process that includes a bleach bath. Stains that do not respond to this treatment will be removed by a reducing solution of sodium bisulfite and zinc dust.		Wool and silk should not be blued with aniline blues, because aniline colors dye these fibers directly. In case this type of blue has been used, the stain may be treated with a permanganate solution or with sodium bisulfite and zinc.		
COCOA AND CHOCOLATE.	Removed in the standard washing process.				
COFFEE.	Removed in the standard washing process.				
CREAM AND ICE CREAM.	Removed in the standard washing process.				
DYE: "BLEEDING" OF MULTICOLORED FABRICS.	Where a multicolored fabric (a stripe or plaid) has bled or run, and the white portion has become colored, it is sometimes possible to remove the stain from the white without affecting the color of the original pattern. Small samples of the material should be tried with javelle water, followed by oxalic acid; permanganate solution followed by oxalic acid or sodium bisulfite; or sodium bisulfite and zinc. The best method can be used on the garment.		In the case of wool and silk, the same methods that are recommended for cotton and linen may be tried, using permanganate solution followed by sodium bisulfite, and sodium bisulfite and zinc. Bleach should never be used on these fibers, but hydrogen dioxide may be substituted for it. Efforts to remedy this condition on wool and silk are not apt to be as successful as on cotton and linen.		
"BLEEDING" OF ONE COLORED GARMENT IN A LOAD OF WHITE GARMENTS.	Where a load of white goods has become colored by the bleeding of a ribbon or similar piece of colored fabric, the treatment is the same as given above, with the addition of caustic soda solution for cotton and linen. The success of the treatment is more assured in this case, however. It is advised that a small, inexpensive garment be taken for purposes of determining the best method.				
HAT DYE.	Soak in 95 per cent. ethyl alcohol, rinse in a clean portion of alcohol, and launder as usual. Slight stains remaining after this treatment may be treated as directed above.				
EGG.	Removed in the standard washing process.				
FRUIT.	Removed in the standard washing process.		Try the following in order: Warm water, oxalic acid, acetic acid, potassium permanganate solution followed by oxalic acid or sodium bisulfite, hydrogen dioxide and sodium perborate.		
GRASS.	Removed in the standard washing process. If any traces remain they may be removed by treatment with javelle water.		Treat with a mixture of equal parts by volume of 95 per cent. ethyl alcohol and ethyl ether.		
GREASE.	Grease stains are usually removed in the standard washing process. If an exceedingly resistant stain is encountered, it may be softened with a mixture of lard and oleic acid (2 parts of oleic acid to 98 parts of lard, by weight) and washed again. When the oleic acid comes in contact with the soda ash in the usual bath, soap is formed, and being in such intimate association with the grease removes it readily.		Stains surviving the regular laundry process must be treated with an excess of soap by hand or with one of the organic solvents, such as gasoline, carbon tetrachloride, chloroform or ethyl ether.		
GUM OR RESIN.	Use the following solvents: Turpentine, benzene, carbon tetrachloride, chloroform, 95 per cent. ethyl alcohol, ethyl ether, kerosene, gasoline, carbon disulfide. The specific solvent must be determined by test, since the solubility of different gums and resins varies. The solvent for common chewing gum, or chicle, is carbon tetrachloride.				
INK: IRON, ORDINARY WRITING.	Treat with warm acetic-oxalic acid mixture (see Chart No. 1, "L. N. A. Standard Formulas").				
ANILINE.	See DYES and BLUEING (ANILINE) for the ordinary writing fluids. No remedy that is harmless to the fabric is known for the black aniline marking ink used in the laundry.				
INDIA.	Removed in the standard washing process. The stain may be loosened by greasing it with lard previous to laundering.				
BLACK PRINTING.	See INDIA INK.				
SILVER NITRATE.	Soak in sodium thiosulfate solution until the stain disappears, or treat with javelle water till stain disappears, then soak in a weak solution of ammonia to remove the silver chloride formed. (If this precaution is omitted the stain will reappear.)		Treat the stain with potassium cyanide solution. (POISON!)		
INDELIBLE PENCIL.	Removed in the standard washing process. Any traces that remain may be removed with javelle water or with potassium permanganate solution, followed by oxalic acid.		Remove the dye with 95 per cent. ethyl alcohol or potassium permanganate followed by oxalic acid. The mineral matter will wash out.		
IRON.	See INKS (IRON).				
LEATHER.	Light stains are removed in the standard washing process. Deeper stains may be treated with javelle water.		No remedy is known which is harmless to the fabric.		
MACHINE OIL.	The oily stain may be removed after the manner described under GREASE. If the stain is caused by a bearing grease, it may contain some iron or other metal, which, however, can usually be removed with the solution used for INKS (IRON).				
MEDICINE: ORGANIC.	Removed in the standard washing process. A very heavy stain may have to be treated with javelle water.		Stains not removed in the standard washing process must be treated with permanganate solution, followed by oxalic acid or sodium bisulfite solution.		
CONTAINING SALTS OF THE HEAVY METALS, LIKE IRON, SILVER, ETC.	Iron stains of this type may be treated as INKS (IRON). Argyrol and other silver stains may be removed by treatment with an excess of potassium cyanide solution (POISON!). This reagent converts the metal to a soluble form that can readily be washed out.				
MILDEW.	Fresh, light stains are removed in the standard washing process. Old stains, however, must be treated with javelle water alternated with oxalic acid.				
MUD.	Removed in the standard washing process. Occasionally there is a residual iron stain that must be treated [see INKS (IRON)].				
PAINT AND VARNISH.	These stains are more easily removed if treated before being laundered. Oleic acid is rubbed into the spot, and the stain is washed with a 1 per cent. solution of oleic acid in kerosene (prepared by dissolving two ounces of the fatty acid in a gallon of kerosene). Repeat the treatment with the kerosene-oleic acid solution, and wash with warm soda ash solution (6 ounces of soda ash to a gallon of water).		Use the following solvents: Turpentine, benzene, carbon tetrachloride, or chloroform.		
PERSPIRATION.	If not removed in the standard washing process, treat with javelle water, or with potassium permanganate solution followed by oxalic acid.		If the stain does not wash out, use potassium permanganate solution followed by oxalic acid.		Where the color is changed, it may sometimes be restored by sponging with a weak acid or alkali.
SCORCH.	Light spots will be removed in the standard washing process, but heavier spots must be specially treated. For this purpose, javelle water, alternated with oxalic acid, may be used; also potassium permanganate solution followed by sodium bisulfite.		Treatment with permanganate solution will partially restore scorched wool and silk, but a heavy scorch can never be removed.		
SYRUP.	Sugar is removed in the standard washing process. Fruit syrup stains remaining after this treatment should be dealt with as described under FRUIT.				
TAR OR TARRY.	See treatment for PAINT.				
TEA.	Tea stains are usually removed in the standard washing process.		Such stain as remains after the standard washing process may be treated with hydrogen dioxide, or with permanganate solution, followed by oxalic acid solution.		
TOBACCO: EXTRACT.	If not removed in the standard washing process, either javelle water or a solution of potassium permanganate followed by oxalic acid may be used.		The substances comprising a tobacco stain are soluble in 95 per cent. ethyl alcohol. Hydrogen dioxide or permanganate solution may be used on any traces that remain after treating with alcohol.		
TARRY RESIDUE FROM PIPES.	See treatment for PAINT.				
TURMERIC.	Usually removed in the standard washing process; if not, treat with javelle water or with potassium permanganate solution. This dye is one of the few permitted to be used in food by the Bureau of Chemistry's interpretation of the Pure Food Law. Some of these permitted dyes resist the action of the above reagents, but they can all be removed with amyl alcohol.		A stain which survives the standard washing process can be treated with potassium permanganate or hydrogen dioxide solution. The discussion of the other dyes used in foods, as given for cotton and linen, holds for wool and silk also.		
VASELINE.	See treatment for WAX.				
VERDIGRIS.	Usually removed in the standard washing process. Older stains may require more drastic treatment, as, for example, with dilute hydrochloric (muriatic) acid.				
WALNUT (BLACK).	Boil in a concentrated soap solution and follow with treatment with javelle water if the gray stain persists. For old stains soak in javelle water, rinse, treat with oxalic acid, and rinse again. This treatment is not always successful.		No treatment can be recommended for wool and silk.		
WAX: PARAFFIN AND OTHER WAXES.	These substances must be sponged with a suitable organic solvent (gasoline, chloroform, benzene, carbon tetrachloride, etc.), or placed between two layers of clean, absorbent material, such as blotting paper, and pressed with a warm iron. The blotting paper removes the paraffin by capillary attraction after the heat has converted it into a fluid state.				

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The Treatment of Stains*

Methods of Stain Removal Adapted to Various Textiles

By Harvey V. Elledge and Alice L. Wakefield
Industrial Fellows of the Mellon Institute of Industrial Research

In our issue of May last we published an article on "Textile Fibers" in which tests were given for the identification of various fibers in common use. The article was abstracted from a booklet published by the Laundryowners National Association, entitled "The Conservation of Textiles." Another chapter from the same source is reproduced by courtesy of the publishers. Although written especially for laundry owners the subject is of general interest, and the accompanying chart together with the instructions for removing stains will no doubt prove valuable to the majority of our readers. —EDITOR.

OUR best advice to the laundryowner is that he choose one of his employes who shall handle all stained fabrics which require special treatment. Such a procedure cannot be urged too strongly because the proper treatment of stains is dependent upon an intimate knowledge of their physical and chemical characteristics and a thorough training in the technic of the application of this knowledge. The physical characteristics of stains are differentiated by such slight degrees in so many cases that word-pictures make an impossible medium for instruction; rather a keenness of perception and a large power of retention, combined with the consistent application of these faculties are necessary for the development of a good "stain identifier."

Having provided oneself with a trained observer, or with a person capable of being trained to observe, the thing to do is to provide a special work bench for the application of the specific knowledge of stain treatment. Only a small bench will be necessary, say the size of an ordinary kitchen table, but it should be given up entirely to the work under discussion and should be specially equipped. It would be well to remember, when choosing the location of this bench, that at times inflammable materials will be used.

In the first place it should be placed in the best light obtainable. This is desirable that slight color differences may be noted and that final results may be accurately judged as complete or partial removal. If only partial removal has been effected, efforts may be renewed along different lines until the stain is completely removed or until the best possible results have been obtained.

The equipment should include all the reagents used in the identification and removal of stains and any apparatus that will facilitate their application. The reagents to be desired are presented in the table on page 54.

There should be "stock" bottles of each reagent; that is, bottles in which the reagent is kept in its original condition and strength. These will be handled only when the solutions to be used in stain treatment are made up. There should be the bottles of solution that are to be kept on hand as "indicators" and as "testers."

The solutions should be carefully prepared. There is no need for using excessively strong solutions because the lessening of the time factor by this method means a corresponding increase in the tendency of the solution to tender the fabric. It is just as profitable for the person who is removing stains "to increase the dose" as it was for the man who increased the dose of headache tablets, and died as a consequence. In both cases the physical condition of the object under treatment is made worse instead of better.

Oxalic Acid.—One ounce of oxalic acid crystals are dissolved in a gallon of water. This solution works more rapidly when warm. Always rinse carefully in clear water after using this acid; if traces of it are left in the fabric it becomes concentrated as the moisture evaporates and tenders the cloth.

Acetic Acid.—This acid is usually found in the laundry as commercial 56 per cent acetic. It can be used in this strength without damage to the fabric, but it is preferable to dilute it with an equal amount of water. As this acid is volatile, that is, as it evaporates with the water, concentration does not occur with drying and tendering does not result from insufficient rinsing.

Hydrochloric Acid.—This acid should be used in weak solutions, not exceeding a 10 per cent solution. This percentage may be purchased from the drug store, and care should be taken to express the percentage desired as it is prepared for pharmaceutical purposes in 10 per cent, 25 per cent and 37 per cent strengths. Careful rinsing is urged with this acid for the same reason that is given under oxalic acid.

Caustic Soda.—A 5 per cent solution is prepared by dissolving an ounce of the solid in a pint of water. This solution is to be used on cotton and linen fabrics only and followed by a good rinsing. The concentration of the 5 per cent solution is not detrimental to these fibers, but in greater concentrations tendering is effected.

Ammonia.—The ammonia sold by druggists is about a 10 per cent solution. It will never be found necessary to use it in this strength and dilution with ten times its volume of water is advised.

Javelle Water.—This reagent is so well known in the laundry that no other discussion will be given than that it is prepared as directed in the L. N. A. "Standard Formulas for Washroom Practice," Chart No. 1. The stock solution resulting from this formula should be diluted at least fifty times before using on fabrics. If rinsing is done with dilute acetic acid water the activity of the bleaching solution will be killed.

Hydrogen Dioxide.—Commonly called hydrogen peroxide, and purchased at the drug store, this reagent may be used full strength. The commercial grade of hydrogen dioxide usually contains a considerable percentage of free sulfuric acid; for this reason great care should be used in rinsing after this reagent has been used. Owing to the presence of the small amount of acid that has produced corrosion when used ignorantly, the idea has sprung up that hydrogen dioxide itself is corrosive. This is not the case, however, and no hesitancy should be felt in using it as a stain remover.

Potassium Permanganate.—One ounce of the crystals is dissolved in a gallon of water. A stronger solution is capable of burning the fabric as effectively as a flame, so should never be used.

Sodium Perborate.—This reagent may be used in solutions of any strength, or made into a paste with water and spread on the fabric to be treated.

Sodium Bisulfite.—A saturated solution of this reagent is prepared by adding it to the water until no more will go into solution. Sodium bisulfite is used alone and in connection with powdered zinc. When zinc is used it should be put into small bags so that it will not settle on the fabric and leave a stain that can only be removed with an accompanying damage to the fabric.

Oleic Acid.—This reagent may be purchased under the trade

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TABLE OF REAGENTS USED IN STAIN REMOVAL

INDICATORS	ACIDS	ALKALIES	OXIDIZING REAGENTS	REDUCING REAGENTS	SOLVENTS	
Phenolphthalein	Oxalic	Caustic soda	Javelle water	Sodium bisulfite	Ethyl alcohol	Carbon tetrachloride
Methyl orange	Hydrochloric	Soda ash	Hydrogen dioxide	Sodium bisulfite used with zinc	Amyl alcohol	Carbon disulfide
Hydrochloric acid and Potassium sulfocyanide	Acetic	Ammonia	Potassium permanganate	Sodium thiosulfate	Ethyl ether	Benzine
		Potassium cyanide	Sodium perborate		Acetone	Kerosene
					Aniline	Gasoline
					Chloroform	Oleic acid

name of "Red Oil," but an effective substitute for it can be prepared in the plant by dissolving some soap in hot water, precipitating the fatty acids by acidifying with strong acid, heating till separation is complete and then cooling. After cooling, the fatty acid will be found as a solid cake on the surface of the water.

Sodium Thiosulfate.—Used in saturated solution, prepared by adding crystals to water until no more can be dissolved.

Potassium Cyanide.—One ounce of the crystals is dissolved in a gallon of water. This reagent is one of the most deadly poisons known; therefore great care is to be observed in its use. If any of it gets on the hands they should be kept away from the rest of the body and from the clothing until they can be washed well. The solution should be thrown out immediately after the treatment is completed, the utensils used with it washed thoroughly, and the bench cleaned of any splashings it may have received. If these precautions are observed no fear need be entertained concerning the use of this reagent.

The successful application of these solutions requires a few common utensils that are listed herewith:

Hotplate (electric or gas),
Nest of enameled bowls,
Scales,
Glass rods (with rounded ends),
White blotting paper.

The actual discussion of the treatment of stains had best be made to follow the *Procedure Chart for the Removal of Stains from Wash Goods*, and will occupy the remainder of this chapter.

Albumin.—The regular standard washing process includes a lukewarm first bath for the purpose of dissolving any albuminous materials that may be present.

Blood.—The albuminous portion of this stain is removed in the first bath of lukewarm water; the stain proper, which is due to the hemoglobin or coloring matter of the blood, is removed in the bleach bath. If the fabric is of the kind that can not be treated with javelle water the stain may be treated with hydrogen dioxide.

Bluing.—Bluing is of three kinds, ultramarine blue that gives the desired color by depositing small insoluble particles of blue on the fabric; prussian blue that dyes the fabric with a soluble dye; and aniline blue that dyes the fabric with an insoluble dye. Ultramarine blue, which only gives trouble by being used too heavily, may be removed by simple washing; prussian blue, which in an alkaline bath is changed to iron oxide and gives a rust stain, has to be treated with oxalic acid solution. The aniline blues, if used too freely, dye the fabric permanently as far as the ordinary solvent, water, is concerned, and must be removed by treatment with oxidizing or reducing agents, according to the nature of the dye used. Javelle water or potassium permanganate solution is used to oxidize these blues on cotton or linen fabrics, while potassium permanganate solution or hydrogen dioxide is used on silk and wool. Sodium bisulfite solution and zinc may be used on both the animal and vegetable fibers as a reducing agent. The potassium permanganate solution treatment is not complete in itself, as it leaves a brown stain of manganese dioxide in the cloth which must be removed by treatment with oxalic acid solution. If it is found necessary to repeat the treatment the excess oxalic acid should be washed from the fabric before more permanganate solution is applied. It is always well to observe the precaution of rinsing from the fabric any excess of solution when two solutions are alternated, because the excess of solution present reacts to neutralize the effect of the other solution in a manner that has no effect in the removal of the stain. There is no need for such useless reactions.

Cocoa and Chocolate.—These stains occur in most cases on white table linens and, when too deep to be removed by the water and soap, are removed by the bleach bath.

Coffee.—Javelle water, applied in the bleach bath, removes this stain effectively.

Cream and Ice Cream.—The principal ingredient that causes trouble in this type of stains is the butter fat present. When this is removed with hot water and soap the stain is usually gone completely. In the case of an ice cream that has fresh fruit juice or a food dye present as coloring matter the stain will be removed by javelle water.

Dyes.—The treatment for a dye stain has always to be determined by a few tests on some portion of the stained fabric. The first trial may be made with javelle water; then with permanganate solution, then with sodium bisulfite solution and zinc. The kind of material involved and the dye itself have to be taken into consideration for the successful treatment of this type of a stain. The removal of hat dyes is facilitated by treatment with 95 per cent ethyl alcohol, in which the greater portion of the dye is soluble. A residual stain may have to be treated with one of the oxidizing or reducing agents prescribed on the chart.

Egg.—This stain is partly albuminous, partly fatty, and, in most cases, will be removed by a formula that includes a lukewarm first bath and hot suds.

Fruit.—Fruit stains can readily be removed by treatment with javelle water; for that reason the stains appearing in cotton and linen garments are said to be removed in the standard washing process. Silks and wools are to be treated with the reagents given in the chart that are not detrimental to them.

Grass.—This stain is also removed from cotton and linen by treatment with javelle water. Silks and wools are treated with a mixture of equal parts of ethyl alcohol and ethyl ether. This is a solvent for the green dye present in grass.

Grease.—The average grease stain is removed in the standard washing process. Any stain that survives this treatment may be softened with oleic acid and lard and washed in a hot solution of soda ash. If the grease has contained a mineral staining agent like iron or some type of dyestuff it can be treated specially as described under these headings. The best treatment to be accorded to silks and wools is with one of the many grease solvents given on the chart. The solubilities of the different types of grease vary with the different solvents, and it is often necessary to experiment with several solvents before the most efficacious one is found.

Gum or Resin.—The type of the gum or resin decides the solvent that should be used. Common chewing gum is soluble in carbon tetrachloride; varnish is soluble in alcohol; resins are soluble in ether, alcohol and turpentine, the source of the resin determining which solvent is best. Since there is no way to decide which resin is present, the method of trial

and error must be applied to discover which solvent is to be used.

Ink.—Iron inks are best removed by treatment with warm oxalic acid. If such treatment does not remove the stain completely it is possible that the ink has been a mixture of iron ink and an aniline dye, in which case a second treatment with javelle water is necessary. India ink and printers' ink are both suspensions of carbon in a gum-like medium, and should be removed in the regular laundering process. If such treatment is not effective the stain may be loosened with lard and laundered again. Silver nitrate inks have to be treated with sodium thiosulfate or with javelle water. Javelle water converts the silver to an insoluble colorless salt that has to be removed by treatment with dilute ammonia water. If this precaution is not taken the silver may again oxidize to the colored salt and the stain reappear. Indelible pencils contain both graphite and an aniline dye; the dye can be removed by treatment with javelle water, while the graphite will be washed away mechanically.

Iron.—The specific treatment for iron stains is warm oxalic acid solution.

Leather.—Javelle water has been found to remove these stains from the cotton and linen fabrics, but in the case of silks and wools the stain is permanent.

Medicines.—The medicines containing organic materials are usually removed in the regular laundry process; any stain surviving this treatment can be treated with javelle water. The medicines containing salts of the heavy metals, like iron, silver, etc., may be treated with potassium cyanide. The cyanides of these metals are water soluble and are removed by means of this solvent after conversion has taken place.

Mildew.—These stains are usually removed in the standard washing process, but heavy stains may have to be treated alternately with javelle water and oxalic acid.

Mud.—The mud itself is removed in the regular water washing but a residual stain of iron is often encountered. This is treated as all iron stains are, with warm oxalic acid.

Paint and Varnish.—These stains are best removed before laundering. They may be loosened by treatment with oleic acid and then laundered or they may be treated with one of the solvents that are given in the table of reagents. The character of the paint determines the treatment applied. Paints are composed of some vehicle and a pigment; the vehicle hardens or sets by the evaporation of some volatile ingredient or by the absorption of oxygen from the air, depending upon its chemical nature. The pigment can be removed mechanically after the vehicle carrying it is dissolved again.

Perspiration.—This stain, being water borne, is usually removed by simple soap and water washing. If it is connected with the running of a dye, treatment for the dye must be applied. Colored goods that have been discolored by perspiration may sometimes be restored by sponging with weak acid or alkaline solutions.

Scorch.—Scorched cotton or linen may be restored by treatment with javelle water alternated with oxalic acid solution, provided the scorch has not completely destroyed some of the fabric. The same results may also be obtained with potassium permanganate and sodium bisulfite solutions. Light scorches on silk and wool may be partially restored by treatment with permanganate solution, but nothing can be done for heavy scorches on these fabrics.

Syrup.—Syrup stains are usually removed in the standard washing process because the medium of the stain, the sugar, is removed. If a fruit juice has been present, some stain may survive this process but the treatment described under Fruit will remove it satisfactorily.

Tar and Tarry.—See treatment of paint.

Tea.—Tea stains are usually removed in the washing process, but the occasional heavy one should be treated with javelle water when it appears on cotton and linen and with potassium permanganate or hydrogen dioxide when it appears on silk or wool. This stain is, in most cases, the result of the tannin present in the tea but in some cases is due to a dye that is added to give a darker color to the infusion.

Tobacco.—The stains from tobacco are usually soluble in the standard washing process, but occasionally stains that require longer treatment are encountered. They may be treated with the oxidizing agents that are permissible with the type of fabric involved or they may, in case of the tarry residue from pipes, be treated with ethyl alcohol.

Turmeric.—This is one of the seven dyes permitted by the United States Pure Food law to be used in food stuffs. They are usually to be removed by treatment with javelle water or permanganate solution, but in cases that do not respond to this treatment amyl alcohol will be found effective.

Verdigris or Copper Stains.—This stain, if not removed by the usual laundry process, has to be treated quite drastically with dilute hydrochloric acid. If only a weak solution of acid is used and care is taken to remove all traces of it afterward, no ill results will be noticed.

Walnut.—This stain is one of the worst encountered on fabrics. It can usually be reduced to a light gray color on cotton and linen by treatment with javelle water, but when on silk and wool no treatment can be recommended.

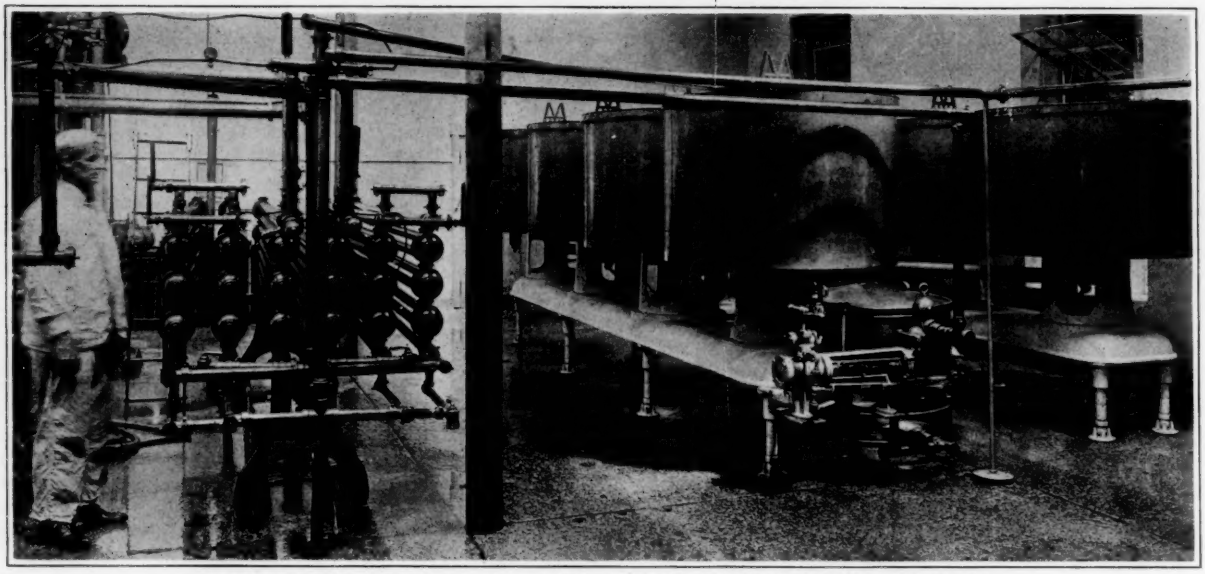
Wax.—The most satisfactory method of removing waxes from fabrics is to place the spot on a piece of blotting paper and apply a warm iron. The heat liquefies the wax and the blotting paper absorbs it. If traces remain after this treatment they may be sponged away with one of the organic solvents.

In conclusion, it is appropriate to suggest that inspection of garments for stains be rigidly maintained in the receiving room. Many times stains are set in laundering and offer a greater problem for removal than they otherwise would.

PERMEABILITY OF BALLOON ENVELOPES

IT has been learned that gases do not pass through rubber according to the simple law formulated by Graham. Both Graham's own researches and those of other investigators show that in this case the phenomenon is much more complex. A German scientist, named W. Franzer, writing in the *Chemiker Zeitung* (Berlin) for August 19, 1920, sums up the work done in the last few years in measuring the velocity with which a rubber membrane or a balloon envelope is traversed by gases, and shows that until recent years the studies published upon this question contained many errors, because of the fact that the hydrogen which had passed through the membrane was weighed in the form of water. Mr. Franzer has devised a method of measurement by means of an interferometer which gives figures strictly proportional to the rate at which the hydrogen passes through the membrane. The results obtained prove that the rubber behaves differently according to whether it is saturated with hydrogen or not.

For a given difference of pressure between the two enclosures separated by the membrane and at a given temperature the velocity of the diffusion of the hydrogen increases, starting from the moment when the membrane or the rubber finished cloth comes in contact with the hydrogen until the moment when the membrane is completely saturated with the hydrogen, after which the rate remains practically constant. This point is rapidly reached when the cloth or membrane has previously been in contact with hydrogen. If the inside surface of the cloth is saturated with hydrogen and if its external surface is in contact with a medium containing no hydrogen then the velocity at which the gas passes and the degree of permeability are both proportional to the rise in temperature. They also increase with the difference of pressure between the two surfaces—in this case, however, not in the same ratio but more slowly. Rubber finished fabrics behave like rubber itself so long as their degree of elasticity is the same. When the pressure becomes higher the permeability increases with the pressure at a very slow rate, since the fabric is less elastic than the rubber and, therefore, prevents the elasticity of the latter from manifesting itself.—Translated for *The Scientific American Monthly* from *Le Genie Civil* (Paris).



PASTEURIZING APPARATUS IN A LARGE NEW YORK MILK DISTRIBUTING PLANT

Clean Milk for Consumers

Present-Day Technique in the Production and Care of Milk

By May Tevis

ONE of the earliest animals to be domesticated even among nomadic tribes was the cow. So valuable is the precious fluid secreted by this dull but worthy animal that in some countries she has even been given divine honors. In India children are taught to revere the cow as their "second mother" and crown them with garlands on certain festival days. So strong is this feeling, according to a Hindu acquaintance of the writer, that an orthodox Hindu would shrink from eating beef as the European or American would from cannibal practises!

But valuable as milk is even for adults and essential as it is in many cases for children, mankind has learned in the last few decades, particularly since the pioneer discoveries of Pasteur, that milk may be a very deadly menace to the health and lives of those who partake of it. This is because it is one of the most favorable of all culture mediums for various disease germs, such as the typhoid bacillus, etc. It is not improbable, indeed, that in the comparatively recent past, after the shipping of milk in large quantities from mixed sources, to cities, because common and before the necessity of modern sanitary precautions was understood, hundreds of thousands of children and adults have been victims of disease carried by milk.

We shall not undertake to discuss the merits of the controversy as to how far bovine tuberculosis is responsible for that disease in human beings. It is our chief purpose here to give an account of the modern practise required by state and city authorities for the purpose of preventing producers and distributors from furnishing helpless consumers with milk dangerous to health from its bacterial content, inferior in nutrive quality, or contaminated by avoidable dirt.

In order that the milk shall contain the required amount of solids and of butter fat it is essential that the breed of the cow be considered first of all. Holsteins, for example, give enormous quantities of milk but it is thin and poor in quality. Jerseys and Alderneys, on the other hand, give a very rich milk, but it is apt to be lower in yield. Not only breed, however, but individual capacity must be taken into account in this connection.

Uses to which Milk Is Put (Calculations Based on Estimates)

Item	lbs. of Milk	Per Cent
Product of 22,768,000 cows at 3,716 lbs. per animal	84,611,350,000	
Disposition of milk product:		
1,650,000,000 lbs. of butter (at 21 lbs. milk)	34,663,850,000	41.0
420,000,000 lbs. of cheese (at 10 lbs. milk)	4,200,000,000	5.0
975,000,000 lbs. of condensed milk (at 2½ lbs. milk)	2,437,500,000	2.9
210,000,000 gals. of ice cream (weighing 6 lbs. to the gallon, 10% fat)	3,150,000,000	3.7
100,000,000 persons; 45% at 0.7 lb. a day (cities) farms with dairy cows, 30%, 1.5 lbs. per day; other farms and small towns, 25%, 1 lb. a day, approximately	36,500,000,000	43.1
17,500,000 calves, whole milk (estimated) requirement	3,660,000,000	4.3
Total	84,611,350,000	100.0

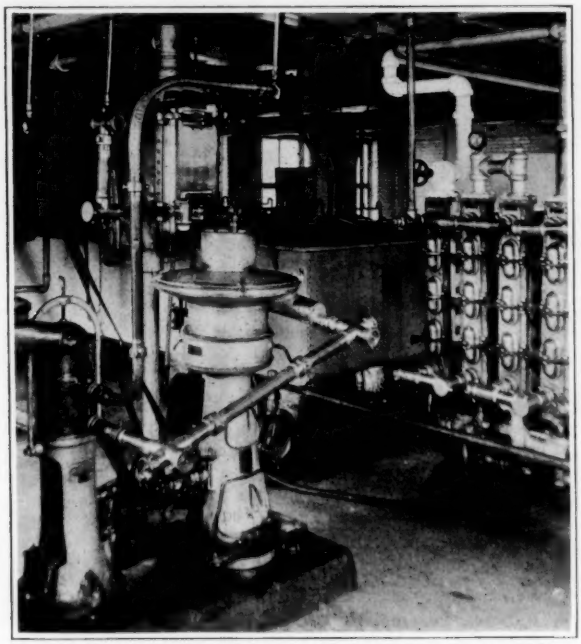
The grades and standards recommended by the National Commission on Milk Standards are as follows:

GRADE A

Raw Milk.—Milk from this class shall come from cows free from disease as determined by tuberculin tests and physical examinations by a qualified veterinarian, and shall be produced and handled by employees free from disease as determined by medical inspection of a qualified physician, under sanitary conditions, such that the bacteria count shall not exceed 10,000 per cubic centimeter at the time of delivery to the consumer. It is recommended that dairies from which this supply is obtained shall score at least 80 on the United States Bureau of Animal Industry score card.

Pasteurized Milk.—Milk of this class shall come from cows free from disease as determined by physical examinations, and

shall be produced and handled under sanitary conditions, and that the bacterial count at no time exceeds 200,000 per cubic centimeter. All milk of this class shall be pasteurized under official supervision, and the bacterial count shall not exceed 10,000 per cubic centimeter at the time of delivery to the



CENTRIFUGAL SEPARATOR FOR REMOVING FOREIGN MATTERS FROM MILK

consumer. It is recommended that dairies from which this supply is obtained shall score 65 on the United States Bureau of Animal Industry score card.

GRADE B

Milk of this class shall come from cows free from disease as determined by physical examination, of which one each year shall be by a qualified veterinarian, and shall be produced and handled under sanitary conditions, such that the bacteria count at no time exceeds 1,000,000 per cubic centimeter. All milk of this class shall be pasteurized under official supervision, and the bacterial count shall not exceed 50,000 per cubic centimeter when delivered to the consumer.

It is recommended that dairies producing grade B milk should be scored and that the health department or the controlling departments, whatever they may be, strive to bring these sources up as rapidly as possible.

GRADE C

Milk of this class shall come from cows free from disease as determined by physical examinations, and shall include all milk that is produced under conditions such that the bacterial count is in excess of 1,000,000 per cubic centimeter.

All milk of this class shall be Pasteurized, or heated to a higher temperature, and shall contain less than 50,000 bacteria per cubic centimeter when delivered to the consumer.

Whenever any large city or community finds it necessary, on account of the length of haul or other peculiar conditions, to allow the sale of grade C milk, its sale shall be surrounded by safeguards such as to insure the restriction of its use to cooking and manufacturing purposes.

These grades and standards have been adopted either directly or with such modifications as local conditions might suggest, in several of the states and cities of the United States, and it seems certain that such grading of the milk supply will soon become the general rule.

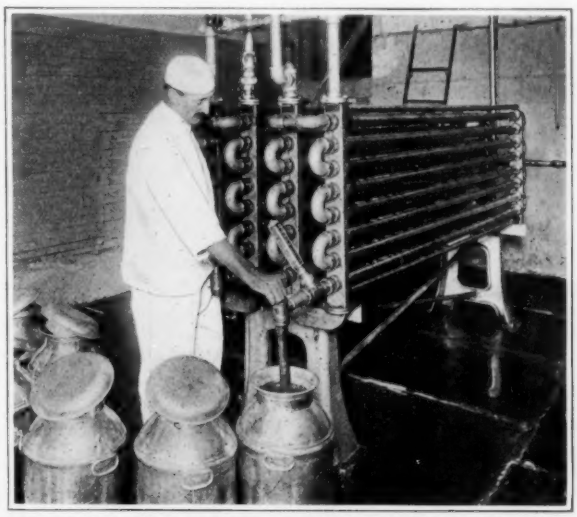
Pasteurization.—Since under ordinary conditions it is not always possible to guard perfectly against the possible introduction of the germs of communicable disease into milk, and since it is now known that a careful application of a suitable degree of heat for a definite period of time will rid the milk of disease germs while injuring its nutritive quality but little, it is generally agreed among authorities that all milk, except certified milk produced under what are popularly called gilt-edge conditions, should be pasteurized, according to the process invented by the famous French savant. This process consists of heating the milk for 20 to 30 minutes at a temperature of 60 to 63 deg. cent. (145 deg. fahr.) Practically the only injury exerted upon the milk when the temperature is kept at this low point is a loss of its vitamines. This is not an especially serious matter in the case of adults living upon a liberal mixed diet, since they may obtain these necessary elements from many other sources, particularly fruits, salads, and green vegetables. But when it is necessary to feed babies and young children upon pasteurized milk they should also be given orange juice at frequent intervals, since this is both easy to digest and uncommonly rich in vitamines.

It must not be forgotten that pasteurized milk becomes freshly contaminated with great rapidity unless care is taken to preserve it in a sterile condition.

Preservation of Milk.—As in the cases of other foods strict cleanliness and the use of sterilized utensils form the best means of preventing deterioration, since in this way the bacteria can be either prevented from entrance entirely, or else retarded in growth, if not destroyed utterly. It has been found by actual experiment that perfectly clean milk protected from air and kept cold will remain sweet and fresh for two or three weeks, if not longer, without other measures.

The superiority in the methods of the best American dairies with respect to cleanliness, was strikingly shown in the Paris Exposition of 1900. Three great dairies supplying metropolitan distributors, one in New York, one in New Jersey, and one in Illinois sent regular shipments of fresh milk and cream to Paris during the summer. These supplies were found to be perfectly fresh and sweet when opened 15 or 20 days after bottling which made European dairy experts express great surprise that the milk had been thus preserved merely by being kept clean and cold.

Certain chemical preservatives are effective in keeping milk



COOLING MILK BEFORE PUTTING IT INTO CANS FOR SHIPMENT IN REFRIGERATOR CARS

from turning sour, though their use is much to be deprecated. The preservatives generally used are formaldehyde and borax or boracic acid. Much more objectionable is the use of ordinary soda, either washing or baking soda, to keep milk

sweet, since in this case the alkali merely neutralizes the lactic acid which would otherwise give the milk a sour taste. The soda does not check the growth of the bacteria but merely hides the results of their growth. Moreover, by neutralizing the lactic acid, which affects chiefly the content of milk sugar, the soda actually favors the growth of other bacteria which feed upon the casein in the milk. Such milk, therefore, actually becomes unwholesome much faster than that to which nothing has been added.

MILK ANALYSIS

The fat content of milk, *i.e.*, the percentage of cream or butter, is of peculiar importance, since aside from its nutritious quality it contains an almost essential fat-soluble vitamine. In some remarkable experiments conducted in Germany during the war to determine the nutritive quality of various foods, it was found that only one or two other fats (one of which was cod liver oil) were capable of taking the place of butter in the diet of rats, which like man are omnivorous. Animals supplied with the most liberal diet, including fats as well as sugar, starches, and proteins, sickened and died unless the diet contained one of these essential forms of fat, preferably butter.

Various tests have been devised for determining the percentage of butter fat in milk, one of the best being that devised by Dr. S. M. Babcock of the Wisconsin Agricultural Experiment Station.

Percentage of Butter Fats.—The "richness" of cream or milk and their value depend upon the amount of butter fat in them. So cream or milk is often called "30% cream" or "20% cream" or "41% milk," according as 30% or 20% or 41% of the fluid is butter fat; 31% cream is quite rich, ordinary market cream varies between 18% and 40%, though it may fall below 18%, or it may be sold as a very expensive article having as high as 60%. Rich milk may contain more than 6% of butter fat and skim milk less than 0.1 of one per cent. The average for good whole milk is between 3% and 4½%.

For a long time scientists and scientific dairymen were the only ones to speak of milk and cream in terms of percentage of butter fat. "Now, however, people are beginning to realize how valuable a part of the milk the butter fat is, and are paying more attention to the actual percentage of butter fat in the cream or milk they use. So it is no longer unusual to see a dairyman advertise cream of a certain percentage or to hear a housewife ask for it specifically," says a recent authority.

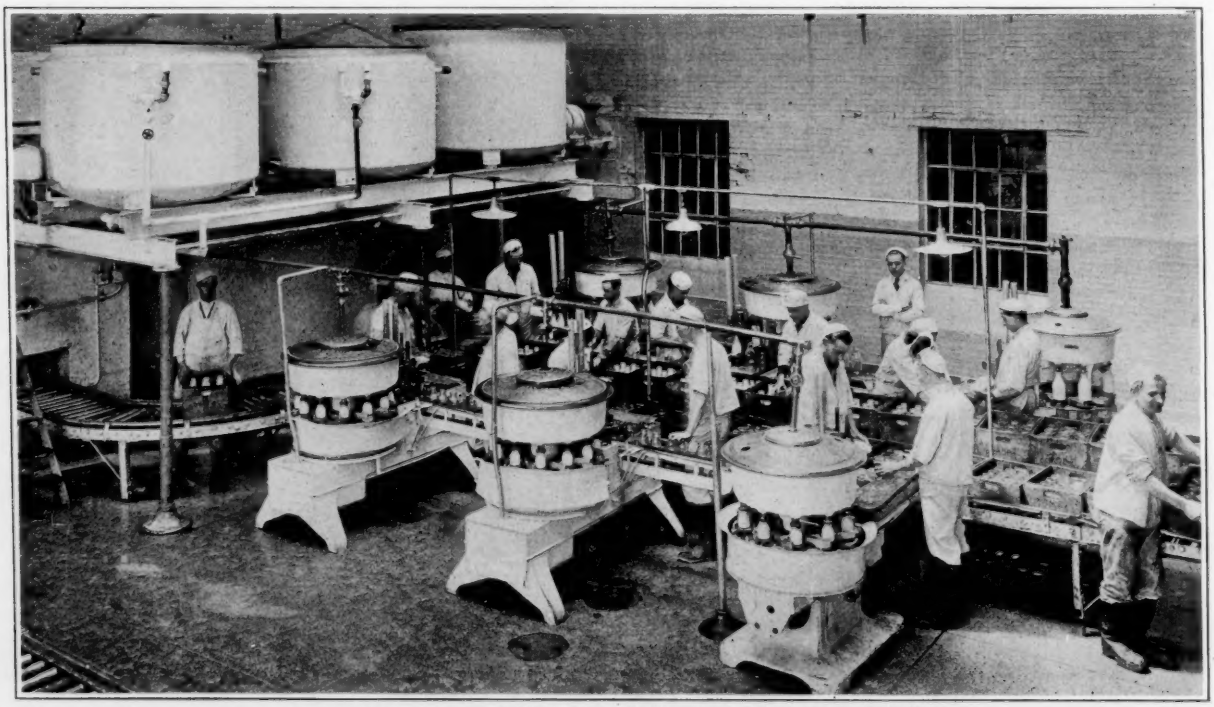
Pasteurized Cream.—This does not look so rich as raw cream, and fresh, sweet cream appears to be thinner than when it is 24 hours old and slightly ripened. So it is well, when buying cream, not to judge by appearances. Demand of the milkman that the cream shall have a certain percentage of butter fat and insist on getting what you pay for. If you have no Babcock tester the milk inspector will test the cream for you.

In making the Babcock Test, a measured amount of milk is treated with about an equal volume of commercial concentrated sulphuric acid which dissolves the other constituents, leaving the fat free in a heavy solution from which it is separated by centrifugal force and collected in the graduated neck of the test bottle, where its volume is read off at ease on the completion of the test. Complete directions are furnished with the testing outfit, which can be purchased for a few dollars from dealers in chemical apparatus or dairy supplies.

TESTING THE COWS

This matter of individual capacity both for yield and for quality is so vitally important that a farmer may actually lose money by keeping milch cows which give so low a yield or so poor a quality of milk that its sale price is less than the cost of the care and feeding of the cow. In such a case the animal is "eating her head off," and milking the farmer's pockets, so to speak. For this reason the milk from each cow is weighed at regular intervals, once a month or oftener, while the Babcock Test is also applied three or four times during the period of lactation. If yield and quality prove that the cow is not worth her keep then "off with her head" the sooner the better.

Health Tests.—The cow must also be tested for tuberculosis, which is done by the application of Koch's well-known Tuberculin Test. While it is not necessary to kill animals which are only slightly infected, this should be done when the lungs or udder are affected. In his recent work "The Story of Milk,"



A BATTERY OF AUTOMATIC BOTTLING AND CAPPING MACHINES

CHEMICAL AND BACTERIOLOGICAL LABORATORY WHERE SAMPLES OF MILK FROM VARIOUS COLLECTING STATIONS ARE EXAMINED TO ASCERTAIN THEIR QUALITIES AND KEEP THE MILK UP TO STANDARD

Johan D. Frederiksen quotes with approval the system of isolating infected animals introduced into Denmark by Dr. Bernhard Bang. This system, combined with compulsory pasteurization of the milk from an affected cow has proved effective in eradicating bovine tuberculosis.

CARE OF MILKING

While milk is almost free from bacteria as it comes from the cow, it is one of the best culture mediums in the world for human disease germs. Hence it is important not only that the cows themselves shall be healthy and clean, but that the milkers shall be in the same condition as regards their own bodies and that their clothing shall be freshly washed. The udders and teats of the animal must be carefully washed, the barn must be kept scrupulously free of dirt and, above all, the ubiquitous fly which, as we now know, is one of the most active agents of infection, must be excluded.

The test for clean milk generally used is called the *Bacterial Count;* it consists of the estimation of the number of bacterial colonies per cubic centimeter. Even fairly good milk often contains several hundred thousand bacteria per cubic centimeter, but where scrupulous cleanliness is observed, as in the preparation of certified milk, this number may be reduced to less than a thousand. City ordinances vary as to the permissible limits in certified milk, ranging from 10,000 to 30,000 per cubic centimeter. These numbers sound rather appalling, but we must remember that large as they are, they are not more than the resistant forces in a healthy human body are equipped to combat.

PRACTICE AT MILK STATIONS

In various parts of the country there are stations for receiving milk, sometimes controlled by coöperative societies of farmers and sometimes by the big distributors. In these the milk is tested and if not up to the standard is sent back to the producer. One sample is taken for the Babcock Test and another for the Fermentation Test. Each producer's delivery is weighed in the "weigh can" and then run through a cheesecloth strainer. In some stations the milk is merely cooled by running it over a cold water or brine cooler and then placed in the shipping cans, after which it remains in ice water or in a refrigerator until picked up by the milk train. In others it is run through a centrifugal machine to clarify it, the impurities being thrown out and deposited on the wall of the vessel, after which the milk is pasteurized and bottled before being shipped. Whether pasteurized in bottles in the country or at the city plant, great care is taken to fulfil sanitary requirements as well as to secure economy. These plants are equipped with very ingenious bottling machines and bottle washing machines as well as with pasteurizers.

CHEMIST TESTING SAMPLES FROM THE PASTEURIZING ROOM

SEPARATING THE CREAM

The writer has a charming memory of the dairy house or "spring house" on her great grandfather's farm in Kentucky. A low stone structure built above a spring of cool water. Here the freshly drawn milk was placed in shallow pans so as to cool quickly and so as to facilitate the rising of the cream by affording it a large surface. Nowadays, however, there is no waiting for the cream to rise, no picturesque skimming of the golden surface with a shallow skimmer. The fresh warm milk is run at once in a steady stream through a machine known as a separator; this separator likewise operates by centrifugal force. There are many separators on the market, but that designed by Dr. Gustaf De Laval is, perhaps, the most successful, and is now used all over the world. The cream runs out through one tube and the skimmed milk by another. By regulating the cream outlet "heavy" or "light" cream can be produced at will. These machines are run either by hand or by power; the former will separate from 200 to 1,000 lbs. of milk per hour and the latter 6,000 lbs. or more. The cream

is graded according to its richness. Ordinary milk contains 4 per cent butter fat. If ⅛ of this milk is separated out containing all the butter fat the cream will, of course, be 8 times as rich as the original milk and is known as 32 per cent cream. If only ¼ is taken 16 per cent cream is produced.

Standardizing Cream.—Rich cream is often reduced to a lower standard, especially for the purpose of making modified milk for infants, or for sale to ice cream manufacturers. Cream to be whipped must be from 24 to 32 per cent rich and must be cold and properly "aged," *i.e.*, it must be kept in ice water from 12 to 24 hours.

Buttermilk and Fermented Milk.—Old-fashioned buttermilk was delicious when drunk fresh from the churn, especially with the golden flakes of butter still swimming temptingly in it, but after the separator came into use the sour, stale, skimmed milk called buttermilk ceased to be appetizing to country-bred persons. In modern practice, however, fresh skimmed milk is ripened with a pure culture of lactic acid bacteria and makes a very agreeable drink of a smooth texture like that of fresh country buttermilk, though it is not so rich as the latter.

THE SUGAR SITUATION

THE sugar produced within the United States is about one-fourth of the total consumption which in 1920 amounted to 92 pounds per capita. The total estimated crop produced in the United States was 2,605,174,000 pounds, of which sugar from beets constituted all but 385,975,000 pounds.

In France a slow but constant progress is being made in re-establishing many of the plants destroyed during the war although it is not expected that all of the plants which were destroyed will be in production until 1925.

In Germany there were 269 sugar beet mills operating during the season 1919-1920 as compared with 307 in 1918-1919 season. Thirty of the 307 mills have passed out of German jurisdiction under the peace treaty. It is important that the beet production was the most available for many years due to weather conditions, improper cultivation of the crops, due to labor and strikes and the difficulties under which agriculture is pursued at the present time. The weight of the beets themselves was about one-half as compared with the preceding year and both the sugar content and purity were lower. The sugar produced amounted to 733,000 tons in 1919-1920, a little more than half that of the preceding year which meant that the production was under the domestic needs. Fortunately there was on hand something over 200,000 tons from the preceding year's crop. At this time Germany finds itself without available stocks on hand, but there is to be an increase in the cultivated area this year and fields are in better condition. The question still remains as to whether labor will be available and later fuel for the operation of the mills.

INDUSTRIAL ELECTROSMOSIS

A VERY interesting paper on this subject is controlled by Mr. F. Rowlinson to *Beama* for April, 1921. The author first reviews in a very clear way the phenomena of exosmosis endosmosis and osmotic pressure; this is followed by an explanation of colloidal state of matter and of the Brownian movements. The author then takes up the electrosmosis phenomenon. If a vessel divided into two compartments by a porous diaphragm be filled with water and that water be subjected to the action of an electric current from an anode and kathode immersed in each compartment, we shall see a migration of water through the diaphragm. The water passes from the anode compartment toward the kathode, and the level in the latter, therefore, rises. If clay be suspended in the water the clay particles will tend to migrate toward the anode. This action, discovered by Reuss in 1807, is termed electrosmosis, from its similarity to ordinary osmosis.

It remained for the German scientist, Count Schwerin to put these properties of matter to industrial use for the purpose of drying peat. The peat experimented upon was highly colloidal in nature and so slimy that although it contained 95 per cent of water, it would not pass through a 60-mesh sieve. Some of this colloidal peat was placed in a wooden sieve with an ordinary wire gauze bottom. On top of the peat an iron plate was placed to serve as one of the electrodes, the other electrode being the gauze of the sieve. As soon as the circuit was closed water immediately began to trickle through the lower gauze and the layer of peat decreased in thickness until it became a thin layer of friable dry material. Patents were taken out and Schwerin applied the process to the drying of peat on an industrial scale. Success was achieved as regards the practical part of the process, and a marketable product of drier peat was obtained. The cost, however, proved rather higher than anticipated, and the process was abandoned in Germany. The margin however was so small that a famous German scientific firm took up the process and spent huge sums in erecting a plant in Switzerland.

The next industrial application of electrosmosis was the purification of clay. The following is a description of an industrial plant for such purposes: The raw material dug from the earth is "blunged" with water and the necessary quantity of alkali and colloidal organic matter to give a differential charge to the clay and the impurities is added. The whole is run into a coarse settling tank to separate the very coarsest fragments of pyrites, dirt and sand. After this preliminary settling, a second may be necessary, or the material may be run straight off into the electrosmose machine. This consists of a wire-lined trough of wood, in which a metal drum slowly rotates. The wire lining of the trough constitutes the negative electrode, and the drum the positive. The clay slip runs in at one end and the excess overflows at the other. Clay begins to deposit on the drum immediately, and the deposit grows continually. Further, the clay deposit is very dry, notwithstanding the fact that it has been formed under the surface of the liquid. The impoverished slip, containing a certain proportion of clay (usually about 10 per cent) is allowed to overflow into a settlement tank, where the very finest impurities, rejected by the electrosmose machine, quickly settle now that the bulk of the clay has been removed. The supernatant liquor is used for a further lot of clay. Clay treated by this process is remarkably fine and plastic. It is used for the manufacture of the best quality ware and particularly for electrical insulation purposes.

A second recent application of electrosmosis is what is known as the Rogers-Bennett process for the extraction of oils from both animal and vegetable sources. In the case for example, of the extraction of oil from the livers of cod or other fish the electrical equipment consists of a steam jacketed steel box containing several (usually 20) sections of two-inch steel pipe. The pipes or "coils" are connected in series by insulating end-sections of rubber hose, so that there is a continuous passage through the whole of the unit by traversing each coil in turn. Down the center of each coil runs a one-inch diameter carbon rod, which forms the negative electrode; the coils themselves form the positive electrodes. Through the half-inch annular space between the positive and negative electrodes a macerated pulp of liver and salt water passes, circulated by a pump. The passage of the current across the salt water and pulp causes an electrosmotic pressure to be developed inside the fat cells. This pressure breaks down the protein envelope of the cells, and the oil contents are discharged. At least 99.5 per cent of the oil is thus set free. The pulp then passes on with its oil in the form of an emulsion, to a screen which separates the solid portions, while the oil and salt water pass on to centrifugal separators of the high-speed continuous type. The separated meal, or solid portion, is an excellent feed, or it may be used as a fertilizer.

Still other applications of electrosmosis to industrial processes on a large scale lies in the extraction of sugar from sugar beet, to new methods of tanning and in the petroleum industry. For each case the author briefly reviews the methods to be used.

Hydrogen from Steam—I

Commercial Processes Utilizing Steam in the Production of Hydrogen

By Harry L. Barnitz, Ph.G.

THE utilization of steam as one of the active reagents in the production of hydrogen is of utmost importance, as it is by its employment in commercial processes for the production of hydrogen, that the greater amount of hydrogen from steam for industry and war purposes is at present made.

Prior to the description of the processes utilizing steam in the commercial production of hydrogen it will be necessary to consider, in the first step, the manufacture of "blue water-gas" in which steam is one of the composite active reagents.

The three processes utilizing steam are:

The Iron Contract Process.

The Badische Process.

The Linde-Frank-Caro process.

All these are commercial processes and employ blue water gas.

PRODUCER GAS

Producer gas is a term which applies to any gaseous fuel obtained from solid fuel in a "gas producer," *i.e.*, coal or coke which is most generally employed and which can be nearly or completely consumed by means of partial oxidation and gives a combustible gas with no combustible residue. The oxygen required for the combustion of the solid coal or coke in making producer gas in actual practice is obtained from the air, from water or from both sources. Therefore, the three principal variations of producer gas may be distinguished as *air-gas*, *water-gas* and *semi-water-gas*, carbon monoxide (or carbonic oxide) CO, being the essential component of each of these gases.

Before describing the furnace required to produce the various gases, some information will be given concerning carbon monoxide. Carbon monoxide is always formed when carbon is burned in an insufficient supply of oxygen or air, but in this case, it is never pure, being always associated with carbon dioxide, thus:

$$2C + O_2 = 2CO$$

The reaction is reversible or takes place in two stages, thus:

$$2C + O_2 \rightleftarrows 2CO,$$

$$CO_2 + C \rightleftarrows 2CO$$

At 1,000 deg. cent. it is nearly complete in the sense of the upper arrow, while at 450 deg. cent. it is practically completely reversed.

Carbon monoxide is a colorless, odorless, tasteless gas which is 0.9672 times as heavy as air at and below 139.5 deg. cent. it may be condensed to a liquid by pressure. The critical pressure is 35.5 atmospheres. The liquid boils at 190 deg. cent. and the white, snow-like solid, formed, melts at 207 deg. cent. in the air and in oxygen; the gas burns with a rather small flame, forming carbon dioxide provided a trace of moisture is present, thus:

$$2CO + O_2 = 2CO_2$$

The above equation is indicated by exploding a mixture of carbon monoxide and oxygen, when two volumes of the former and one volume of the latter form two volumes of carbon dioxide. From this fact and the fact that 22.4 liters of carbon monoxide under standard conditions weighs 28 grains, it follows that the formula for the gas is CO. The result of the above experiment is only determined when the composition of carbon dioxide is known.

The heat liberated on combustion of carbon monoxide amounts to 68 calories per gram-molecule. The heat liberated from the formation of carbon monoxide from carbon being also exothermic is 29 calories per gram-molecule. Therefore, the thermic equation may be indicated thus:

$$2C + O_2 = 2CO + 58 \text{ cals.}$$

$$2CO + O_2 = 2CO_2 + 136 \text{ cals.}$$

and where combustion is complete

$$C + O_2 = CO_2 + 97 \text{ cals.} = \left(\frac{194}{2}\right)$$

It is evident, therefore, that about 30 per cent of the heat obtainable by complete combustion is evolved in the conversion of carbon into carbon monoxide.

Therefore the theoretical yield for 1 pound of carbon is

$$C \rightarrow CO \rightarrow CO_2$$

weight 1 lb. → 2 1/3 lbs. → 3 2/3 lbs.

Heat → 1,096 cals → 2,571 cals.

Total → 3,667 cals.

Carbon monoxide is a strong reducing agent. It is able to abstract oxygen from many metallic oxides at higher temperature and it may itself in turn be reduced by still stronger reducing agents.

Carbon monoxide is readily absorbed by an ammoniacal or hydrochloric acid solution of cuprous chloride. Carbon monoxide may be expelled from the solutions by heating. The acid solution of cuprous chloride is used in estimating carbon monoxide in gas analysis.

Carbon monoxide is a very poisonous gas and the fact that it is odorless makes it more so as it does not betray its presence till it has already produced toxic effects. The gas unites with the hemoglobin of the blood forming an addition product which is bright red in color and very stable. One-twentieth of one per cent. of carbon monoxide in air exerts toxic effects. Traces of the gas may be detected by shaking the suspected air (after freeing, if present, from ammonia and sulphuretted hydrogen) with a solution of palladium chloride 0.05 per cent which is sufficient to produce a precipitate. Cases of carbon monoxide poisoning should be treated by removing the patient into warm, fresh air, application of warm artificial respiration, and the administration of oxygen under a pressure of one to two atmospheres. Medical aid should be sought.

PRODUCERS

It is not the author's object to treat in detail the subject of producers, but to give only a general outline sufficient to make clear the mode of action of producers as an adjunct to the production of hydrogen. There are many types of producers and various extended uses. A producer lends itself to the utilization of a great variety of fuels. The temperature and economy obtained depend to a great extent on the design of the furnace and burners and type of grate used and the manner in which the air blast is admitted. The chief aim of modern producers is to effect the various stages of gas production by mechanical means as far as possible, and thus render the whole process continuous.

Gas producers are known as *wet* and *dry*, but they are all worked on practically the same principle.

AIR GAS

In a dry producer, coke—coal or other suitable fuel—is carried on a grate surmounted by a brick-lined cylinder of steel plate, on the top of which is a hopper or fuel feeding box. Air is blown by a fan under the grate, which is also enclosed in the outer casting. It converts the fuel (*i.e.*, coal or coke) on the grate into CO_2, and heats that above it to an incandescent temperature.

The CO_2 which rises through this hot fuel on its way to the outlet pipe absorbs a second atom of carbon, and the result is thus expressed:

$$CO_2 + C = 2CO,$$

carbon monoxide being formed as shown in Fig. 1.

When such an apparatus is worked with air blast only the resulting gaseous fuel is known as air gas. The amount of air supplied must not, of course, be sufficient to oxidize the fuel to the fullest extent, since what is aimed at is the production of the maximum amount of carbon monoxide, and the minimum amount of carbon dioxide.

Naturally the composition of air gas will depend on the material of the fuel employed. An ideal gas obtained from pure air and carbon would consist, by volume, of carbon monoxide, 34.7 per cent and nitrogen, 65.3 per cent. However, in actual practice it is impossible to avoid a small percentage of carbon dioxide and if coal is used (not coke) a small amount of methane (which is valuable as a fuel) is always present owing to the distillation of the coal on the top layers in the producer.

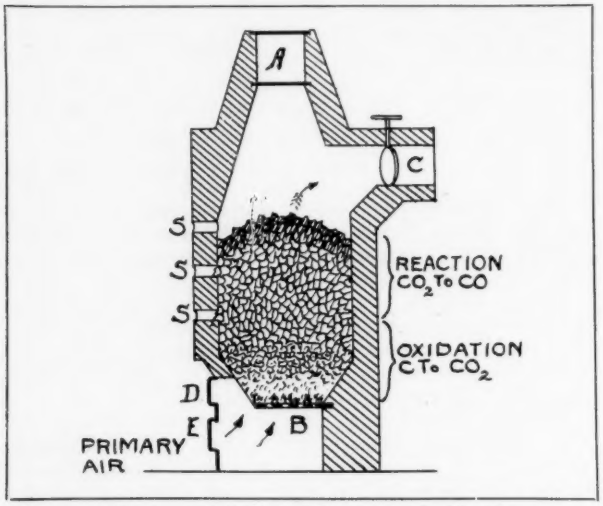


FIG. 1. SECTION THROUGH A PRODUCER

Hot air entering at *E*, and passing through the fire-bars, burns mainly to carbon dioxide in the lower part of the furnace, then passing through the upper layers of red-hot fuel, it takes up more carbon and is reduced to monoxide. The resulting air-gas passes through the exit *C*. *A* is the charging-hopper for fuel, *SSS* are holes for poking, etc., and *D* is a door for cleaning the fire-bars

The following is the usual analysis of air gas:

	COAL No. 1 % by Volume	COKE No. 2 % by Volume
Hydrogen	5.35	1.0
Carbon Monoxide	29.0	32.6
Methane	2.05	....
Total Combustible Gases	36.4	33.6
Carbon Dioxide	2.0	1.4
Nitrogen	61.6	65.0
Total Incombustible Gases	63.6	66.4
Calorific Power, B.T.U. per cubic foot	130.8-138.7	114.5-115.0

Air gas is used for same purposes as semi-water gas, but is considerably less employed as it is by no means as economical.

WATER GAS

Water gas, also termed "blue water gas," is the most important of the varieties of producer production gases, so far as its relation is concerned in the generation of hydrogen.

In the manufacture of water gas, the oxygen required for the combustion of the solid fuel is obtained, not from the air *but from steam*. The fuel is burned by air to a high degree of incandescence, and the gas is sent to waste, *steam* is then sent without air through the hot fuel and the resultant gas is almost wholly combustible.

In the production of this gas no carbon dioxide (CO_2) is intended to be formed, but a slight amount gets through the gaps in the fuel unconverted. Nor should there be any free oxygen in the gases produced. Where the fuel is of considerable depth the burden in the producer is heavy, and the fuel becomes better consolidated and free from caves, and less carbon dioxide (CO_2) and nitrogen (N_2) get through unconverted. The reacting materials should be maintained at a temperature not below 1,000 deg. cent. in order to prevent the formation of more than a negligible proportion of carbon dioxide in the manufacture of water gas.

Ideal water gas should consist of 50 per cent. of carbon monoxide and 50 per cent. of hydrogen by volume. However, in actual practice small amounts of carbon dioxide and nitrogen cannot be avoided. Water gas has the following average composition:

	Volumes.
Hydrogen	49.0 per cent
Carbon Monoxide	43.0 per cent
Methane	0.5 per cent
Total Combustible Gases	92.5 per cent
Carbon Dioxide	4.0 per cent
Nitrogen	3.5 per cent
Total Incombustible Gases	7.5 per cent
Combustible and Incombustible Gases	100 per cent
Calorific power, B. T. U. per cubic foot	290 to 340 per cent

This gas is particularly applicable to high flame temperature and furnace work, especially in reduction of oxides and where a reducing flame is desired.

The efficiency of the generating apparatus of a water gas outfit is about 80 per cent. The generator requires auxiliary apparatus to furnish steam and air for the generation of the gas. Including this fuel, the overall efficiency of the plant is about 61 per cent.

SEMI-WATER GAS

Semi-water-gas is what is generally termed "producer gas" and is always understood to be such when the term is thus employed. It is produced by blowing steam and air simultaneously through red hot coal, coke or other carbonaceous fuel in a type of gas producer such as shown in Fig. 2, employing the same producers as that in which "blue water gas" is made —the difference being in mode of operation.

Ideal producer gas in theory is expressed by the following equation:

$$2C + O = 2CO,$$
$$\text{and } C + H_2O = CO + H_2,$$

and would have the following composition by volume:

Carbon Monoxide	39.9 per cent
Hydrogen	17.0 per cent
Nitrogen	43.1 per cent

whereas in actual practice the gas from the following typical analysis by Sexton shows considerable variation in samples of producer gas:

ANALYSIS OF SEMI-WATER GAS

	No. 1 %	No. 2 %	No. 3 %	No. 4 %	No. 5 %
Hydrogen	8.60	12.13	10.90	19.43	12.60
Carbon Monoxide	24.40	26.40	27.00	16.15	20.40
Methane	2.40	2.00	1.28	2.66	3.50
Carbon Dioxide	2.20	9.16	4.50	11.53	5.50
Nitrogen	59.40	50.31	56.32	50.23	58.00

Semi-water-gas is employed for many purposes in furnaces for tempering and annealing steel, melting brass, copper and aluminum, soldering, drying, japanning and in the baking of enamel on metal. In this work the gas need be neither cooled nor scrubbed clean. It also is employed to a great extent as power for gas engines. Semi-water-gas lends itself admirably to metallurgical work, as with the gas an oxidizing or reducing flame may be obtained as desired. It contains more hydrogen and carbon dioxide and less carbon monoxide and therefore a smaller calorific power. It is more economical than air-gas and is used far more extensively. Under certain modifications of method in producing semi-water-gas it is possible to recover the nitrogen of nitrogen-containing fuels, as ammonia.

PURIFICATION OF THE BLUE WATER-GAS

It is necessary to purify the crude water gas used in the production of hydrogen. The water-gas should be freed from the impurities which it mechanically contains, such as ash and dust, carried by the gas from the producer.

To remove the mechanical retained impurities, the water-gas is passed up through a tower, down which water is falling —this is termed, scrubbing the gas with water. This water scrubbing removes the mechanical retained impurities and, at the same time, reduces the temperature of the gas and causes the condensation and removal of the small quantity of iron carbonyl in the gas.

The removal of sulphuretted hydrogen from the water gas, which is necessary, is ordinarily accomplished by passing the gas at about 55°-65° F. over hydrated oxide of iron, contained in rectangular steel boxes, with the following reaction:

$$Fe_2(OH)_6 + 3H_2S = 2FeS + 6H2O + S$$

In the course of time, the hydrated ferric oxide ceases to absorb and is then directed through other hydrated oxide. The spent oxide is removed, moistened with water and exposed in the open air for revivication and after this treatment is again ready for use. Each revivification increases the free sulphur content approximately 7 per cent and with continuous revivification, the iron oxide increases to 50-60 per cent sulphur. Approximately 1 ton of oxide will purify 2,000,000 cubic feet of gas before it is finally spent. In practice 100 tons of hydrated ferric oxide will purify 200,000 cubic feet of crude water-gas per 24 hours—allowing a reserve of 25-30 tons "revivified" oxide.

In winter, where the temperature is low, it is necessary to provide the purifiers with steam coils, otherwise no absorption of sulphuretted hydrogen takes place, owing to the fact that water is produced which freezes on the surface of the hydrated ferric oxide, and prevents further sulphuretted hydrogen from coming in contact with it.

To prevent back pressure due to packing or caking of the ferric oxide, 15 per cent of water by weight is usually added and either sawdust, approximately 1 part to 5 of oxide by volume, or some spent oxide (containing considerable free sulphur) is mixed with the new oxide. To keep the oxide alkaline, usually 1 per cent of lime is added.

PRODUCTION OF HYDROGEN BY THE IRON CONTACT METHOD

One of the methods that has found favor in recent years for the production of hydrogen in installations of large commercial capacity is the so-called "iron contact method." It is by this method that the greater amount of the world production of hydrogen for use in industry and war is at present made.

The generating elements employed by this method are coke and water, and through them hydrogen can be produced of almost "chemical purity," *i.e.*, of a purer grade than by many other technical processes for large production excepting the electrolytical.

The iron contact method is cyclic with respect to the "iron contact mass"; that is, this iron contact mass is used over and over again. If red hot iron is sprayed with a jet of steam, the iron is oxidized and forms iron oxide, while hydrogen is liberated. If the iron oxide thus produced is treated with reducing gases, such as generator gas, water-gas or illuminating gas, the iron oxide is reconverted into sponge iron.

All these reducing gases consist chiefly of a mixture in varying quantities of carbonic oxide, hydrogen and hydrocarbons.

In practice blue water-gas is now used exclusively in reduction—as such a gas rich in hydrogen greatly accelerates the process of reduction.

The reactions used in the iron contact process may be represented by the following formulæ:

(1) Oxidation: $Fe + H_2O = FeO + H_2$.

(2) Reduction: $2FeO + H_2 + CO = 2Fe + H_2O + CO_2$.

It will be observed that equation (2) is exactly the reverse of equation (1) at least as far as steam is concerned.

The reaction takes place at the surface of the "contact mass." Only where the fresh gases enter, a powerful and far-reaching reaction generally takes place, while the reaction generally decreases in intensity in the direction of the outlet of the gas.

Compact iron, such as waste or filings, is little suited as a contact substance for the process, but iron oxide, either artificial or natural, *e.g.*, iron oxide clay briquets or iron ore, are suitable, but preferably to be recommended is calcined spathic iron, the purest form in which ferrous carbonate ($FeCO_3$) occurs in nature. All these substances become more or less porous during the reducing process.

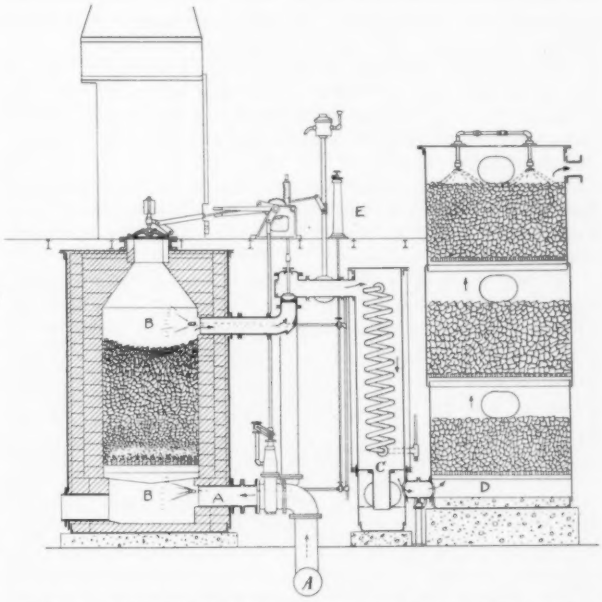


FIG. 2. BLUE WATER-GAS APPARATUS WITH OPERATING FLOOR

A, air blast; *B*, steam supply; *C*, cooler; *D*, scrubber; *E*, operating floor

Theoretically speaking, the contact mass could be used over and over again indefinitely in accordance with the before mentioned formulæ so that an unlimited quantity of hydrogen could be produced by means of a limited quantity of contact mass.

In practice, however, a limit is placed to the life of the contact mass by the fact that as it is only the surface of the latter that is being acted on. The substance gradually becomes impregnated by the dust, silicic acid and sulphides liberated by the gases. These impurities form a layer on the surface, diminishing the reacting capacity, so that the yield of hydrogen

is gradually lowered and other disadvantageous combinations take place.

It is necessary, therefore, to renew the contact mass periodically, say after the plant has been in operation for from 8 to 30 days.

The principal difficulty with the iron contact method arises from the fact that a considerable amount of heat is absorbed during the various stages of the process by the chemical reaction. It is therefore not easy to keep the contact mass at a correct temperature without overheating. If overheated, the contact mass loses its porosity, cakes and even melts. This renders the replacing of the contact mass difficult or even impossible. The action of the gases becomes defective and the yield of hydrogen falls considerably, as channels and cavities are formed which can no longer be acted upon regularly by the gas and steam.

As the iron contact method is very old, all kinds of suggestions have been made in the course of time in connection with the practical method of dealing with this process. A voluminous mass of patent literature on this subject is in existence. Only the most important of these patents, most of which have long ago expired, are here passed under review.

Giffard, who made the method public in 1878, may be considered the discoverer of the method. He employed a shaft filled with ore which he heated and reduced by means of gases coming from a producer connected with the shaft and which passed through a dust chamber, in order to remove the particles of dust introduced during the operation. The defect of this system was that the ore was easily contaminated by the impurities contained in the gases and that a sufficiently high temperature could not be maintained.

In 1889 Claus (English Patent No. 50) published a method for the production of hydrogen in a shaft furnace. He, too, employed "porous though solid blocks of iron oxide" which he alternately reduced with water gas and oxidized by means of superheated steam.

Walker's English patent No. 8373, dated 1890, describes the operation of the contact method in iron retorts, which were heated in a retort furnace from the outside. He employed water gas for the reduction.

In 1892, the firm of Krupp published various improvements of the process (D. R. P. No. 73978) which, however, did not produce satisfactory results and were ultimately rejected.

Iron ores were employed in heated shafts or retorts and attention was drawn to the importance of employing reducing gases as rich as possible in hydrogen with a minimum of hydrocarbon.

Stracke returned in 1893 to the Giffard shaft furnaces (German Patent No. 77,350) and filled a shaft furnace with layers of "iron, iron oxide and ore in any form," heating and reducing the whole by heated generator gas or water gas which he introduced through the ore from the generator. He used charcoal in the generator in order to avoid the formation of sulphur compounds while producing exceptionally pure gas. The waste gases formed during the process of reduction were completely consumed in a superheater with fireproof cage-work which served to raise to a high temperature the steam used in producing the hydrogen. Here too the heating was insufficient.

Schimming took out a German patent, No. 95,071, for the preliminary heating of the reducing gases which he achieved by blowing air into the reducing shaft in order to cause combustion of a portion of the reducing gas. This method had the grave defect of over-heating and melting the ore at the entrance, while the ore further away was not sufficiently heated. He tried to remedy this defect by mixing pieces of fire brick with the contact mass in order that the former might retain a portion of the heat, but the system involved serious drawbacks.

Caro, in German Patent No. 249,269, tried to overcome the want of uniformity in the heating by introducing air to the ore mass at various points during the reducing process. It is evident that under this system the reducing capacity of the gases was seriously affected, so that the yield of hydrogen was altogether too low.

Lewes's English patents, No. 4134 and No. 20752, dated 1890 and 1891, once more describe the iron contact method in detail. He proposed to lay a retort with iron contact mass directly through a water gas generator, which was technically hopeless owing to the consequent overheating. He proposed for the first time to employ porous briquets made of iron oxide and clay or asbestos and then pressed and burned. He employed water-gas for reducing, justly pointing out that the use of such gas rich in hydrogen greatly accelerated the process of reduction.

Hills describes in his English Patent, No. 10,356, dated 1903, the production of hydrogen by the iron contact method which he proposes to carry out in iron retorts. Unimportant improvements in the apparatus employed in the already well known process were patented by him. He used water-gas for the reducing process.

Elworthy, in German Patent No. 64,721, dated 1905, discusses the contact method exhaustively. He notes as the chief defects the tendency of the mass to melt and the choking of the retorts. He proposes to overcome this difficulty by using furnaces in which the spongy iron is contained in specially constructed fire-clay holders. The use of iron in lumps of varying size is taken for granted. By "iron" he always means spongy iron, produced by reduction from iron oxide or iron ore, as, he explicitly states in his English Patent No. 12,461, dated 1902. He employs water-gas for the reducing process.

Lane constructed installations in Russia, France and England about 14 to 16 years ago on the iron contact method. He used chiefly briquets similar to those suggested by Lewes, made of iron oxide and clay which were reduced by water-gas in iron retorts, in large iron retort furnaces. The installations proved, however, to be of inferior working capacity as in the case of the proposals made by Walker (1890) and Hills (1903).

The International Hydrogen Company, whose shares are held by the Berlin Anhalt Machine Construction Company of Berlin, thereupon duplicated the identical method. The result was the same as in all other previous cases.

The inevitable difficulty of the retort system lies in the fact that the retorts are destroyed by fire after being a short time in operation besides being choked by the ore.

Heating of the retort furnaces entails the use of a special system of coke firing, built in the retort furnaces, and involves the use of a considerable amount of coke (about 1,200 to 1,500 kilos per furnace daily). The latest designed (1917) retort generator employs blue water-gas for heating the retorts.

The oldest system employed by Giffard, already referred to, undoubtedly possessed important advantages over this system, but the difficulty of heating was a very serious one as is shown by the above mentioned extracts from the patent literature on the subject. Recently, however, after exhaustive experiments, many of the difficulties connected with the rational carrying out of the iron contact method in large industrial plants have been to a great extent overcome, such as rapidity in getting the plant into working order, more certainty of operation, and simplicity.

Giffard suggested ore as a contact mass. When properly treated, specular iron ore, red hematite and iron oxide hydrates have generally been found suitable. The use of purple ore was protected by Patent No. 220,889 and that of sparry iron ore by Patent No. 241,669 (dated 1911). The former has the disadvantage of containing too much sulphur and cakes easily, while the latter often melts too easily.

Their use, therefore, offers no advantages. As a rule briquets act too slowly, owing to their defective porosity.

According to German Patent No. 244,732, taken out by the International Hydrogen Company, spongy iron free from carbon can only be produced by reduction and out of it pure hydrogen, when instead of the usual water gas, a gas con-

sisting chiefly of hydrogen, but absolutely free from hydrocarbons, is employed. In practice this assertion has not been found to be warranted, as there exist no practical methods of producing such a gas.

The Badische Aniline & Soda Manufacturing Company has admitted in a recently announced patent that spongy iron produced by a reduction from iron ore by means of coal in Sweden for smelting purposes is suitable for the preparation of hydrogen. Experts have long been aware that the maintenance of a proper temperature is indispensable for the production of spongy iron free from carbon. If this is done, any reducing gas, even pure carbonic oxide, may be used for reducing, but water gas has the advantage of acting more quickly, as has been decided by experts who investigated the matter several decades ago.

(To be continued)

Tetralin and Dekalin

A New Illuminant, A New Lubricant and a New Source of Synthetic Drugs

THE once rejected coal tar which has become a veritable Aladdin's cave of riches has by no means exhausted its possibilities of benefit to mankind. One of its well-known products is naphthaline, which is readily separated from the "heavy oil" fraction because of the ease with which it can be crystallized. On this account undesirably large quantities of this product tend to collect in coal tar works and are not readily salable in spite of its very low price. While it is true that naphthaline has long been employed in the dye industry, especially for making the so-called nitro dyestuffs as well as artificial indigo, these industries do not suffice to absorb the whole product. Naphthaline has been used also for making lamp black, but this is hardly to be considered a highly economical employment.

Early during the Great War a German professor, mindful of these things, succeeded in working out a commercial process based upon earlier laboratory experiments by means of which naphthaline is united with hydrogen to form fluid substances of peculiar nature and exhibiting commercially valuable properties. While, as we have said, these "hydration projects" of naphthaline had already been prepared by laboratory methods, these were both tedious and costly; German industry has found itself greatly indebted, therefore, to professor, Dr. G. Schroeter, for finding a capital solution of the problem. This problem consisted technically in uniting the hydrogen which is produced by a well-known process from water and coke according to the equation:

$$C + 2H_2O = CO_2 + 2H_2$$

Carbon plus water equals carbon-dioxide plus hydrogen, in as continuous a process as possible with the naphthaline. This problem had already been partly solved in the industrial process in which liquid oils are hardened by the addition of hydrogen so as to be available for solidifying tallow for the purpose of making soap and oleomargarine; in this process substances called "hydrogen-catalyzers" are employed for the carrying over of the hydrogen. These possess the property of forming loose compounds with hydrogen, somewhat comparable to metal alloys, and thereby they cause the hydrogen to become "active," *i.e.*, capable of chemical reaction. Only small quantities of these catalyzers are required since the "alloyed" hydrogen begins at once to be given up to the substances undergoing hydration, so that the catalyzer is continuously available for forming the pseudo-alloy with new quantities of hydrogen. But the application of this process to naphthaline offers difficulties; the technical form of naphthaline is not capable in fact of such a catalytic absorption of hydrogen without previous preparation; it must also in its turn be "activated" by preliminary treatment and, of course, the process by which this is done must be neither costly nor complex.

It was found by experiment that what is known commercially as "warm pressed stock," *i.e.*, crude naphthaline compressed while still warm into cakes (a form which can be shipped by rail without packing) can be "activated" or "detoxified" sufficiently for the purpose in question by fusing it and stirring it up with small quantities of very finely divided or else readily fusible metals, such as sodium, potassium, etc., and then distilling under lowered pressure. Naphthaline prepared in this manner is united while still in a fused condition with hydrogen, by means of catalyzers in a continuously carried on process, within compression vats; in this manner it is changed into the desired hydro-naphthaline, and the latter is then distilled in a vacuum. The resultant products are divided according to the number of hydrogen atoms taken up by the naphthaline during the process of hydration into tetra-hydro-naphthaline, known in brief as *tetralin* and deka-hydro-naphthaline (dekalin for short) both of which can be produced in the prescribed manner without loss and at a very moderate cost.

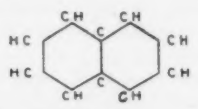
Simple as these processes appear to be, many difficulties were found in adapting them to use on a large commercial scale, particularly in the present economically difficult times; the credit for this placing of the matter on a commercial basis belongs to the Tetralin Company, especially to Mr. H. V. Gwinner and Mr. W. Schrauth, who have carried out the technical arrangements for putting the Schroeter process in technical operation and now have in commission a large plant capable of turning out about 100,000 kg. of this liquid hydro-naphthaline per day.

Tetralin and dekalin are colorless, readily flowing fluids having a boiling point of 260° C. or 189° C.; they have a lower specific gravity than water (D^{20}=0.97 or 0.89); they can be employed as a form of fuel, *e.g.*, in "tetralin-cookers," or to drive motors, in which case they are mixed with benzine.

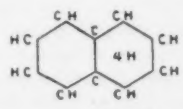
Dekalin can be burned in any perfectly clean kerosene lamp and yields a bright flame without either smoke or odor, and one which is not only economical but also quite safe, since the ignition point of dekalin is very high.

Both tetralin and dekalin are extremely useful as solvents for resins, oils, etc., thus furnishing economical substitutes for imported products.

Chemical transformations of tetralin and dekalin.—According to the chemical formula assumed for the naphthaline molecule ($C_{10}H_8$) its structure may be represented by two rings each of which contains six members consisting of carbon atoms, but with two members in each ring common to both these, so that a "twin nucleus" is formed in which each of the two parts has the chemical character of a benzene-nucleus. By the introduction of 4 hydrogen (H) atoms into one of these nuclei, however, the latter is deprived of its "benzene character," while its "twin sister" appears still to cling to its original chemical character, corresponding to the formula.



Naphthalin.



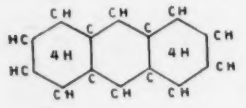
Tetralin.

We have been obliged recently, however, to somewhat modify this original concept of the tetra-hydro-naphthalin formula, it is true, but in a certain measure it still holds good. The

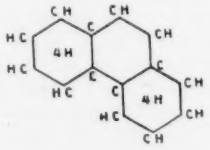
benzene character is expressed particularly in the fact that the benzene nucleus readily unites with nitric acid and with sulphuric acid in such a manner that "residues" of the nitric acid and the sulphuric acid are formed, and from these "intermediate products" there are produced, through further transformation, those medicines, dyestuffs, perfumes, and explosives, which were indicated in the beginning by the reference to benzene and toluol. Thus we see that tetralin also may be looked upon as a source of many substances of this kind.

But the hydrated "twin sister" has also acquired peculiar characters; one of the ways in which this is revealed to us is the manner in which it acts in the body of a dog. Considerable quantities of tetralin can be absorbed by a dog without injury to its organism; the latter does not excrete the tetralin as such; the tetralin is first transformed through the absorption of oxygen by the hydrated nucleus, into an alcohol, and this alcohol is partly transformed in its turn by combination with the urea of the body into a *tetralin-urea*. This observation led to the further one that besides the oxygen in the body of an animal suitable "transmitters" are capable of readily transforming the tetralin into an oxidation product—the so-called "tetralon"; this new product is formed by the substitution of one oxygen atom for 2 hydrogen atoms in the hydrated nucleus; this substitution also makes the hydrated nucleus highly capable of reaction, but this in a manner quite different from that of the non-hydrated nucleus—and we can here obtain a new series of "intermediate products" which promise to be valuable from the technical point of view.

Let us close this brief account of these remarkable and valuable new products by the following observations: When the chlorine compound consisting of a combination of Cl with the metal aluminum (Al), *i.e.*, aluminum chloride is added to tetralin in small quantities at a moderate temperature and the mixture well stirred, then the hydrated twin nucleus will be severed, benzene will be formed by the isolation of the non-hydrated nucleus, and the split off hydrated portion of the nucleus will attach itself to other tetralin molecules, thus forming "triplet-nuclei," to which we have given the names "octhacene" and "octantrene," because of the fact that they are formed from the anthracene and the phenantrene of the coal tar by the taking up of 8 (octo) hydrogen atoms.



OCTHRACEN



OCTANTREN

These hydrated triplet-nuclei are related to many plant alkaloids of great medicinal value, especially to those of the opium group, such as morphine and codeine, so that we are justified in cherishing the hope that these easily obtainable substances may form the starting point for the production of certain synthetic medicines—so that the chemistry of these "aromtic" hydro-products seems destined to add to the treasures of pharmaceutical products.

From this point of view let us recall the peculiar behavior, noted above, of tetralin in the body of a dog, and mention, in addition to this, the long-known effects—both mydriatic and toxic—of the ac. β-amino-tetralin, which contains the ammonia-residue in the hydrated part of the nucleus. We have further succeeded in demonstrating that *the phenols of the tetralin series surpass all other phenols in their powers of disinfection;* an admirable proof of this is found in the fact that they are capable of destroying, even when applied in the form of a very dilute solution, the highly resistant spores of anthrax, and this in a very short time.

Dekalin, too, in which both parts of the nucleus of the naphthaline are completely saturated with hydrogen, is susceptible of undergoing peculiar chemical transformations—however, the paths of investigation along this line are opening but slowly before the chemist; at any rate we believe we have proved our thesis as to the economic and scientific interest which attaches to the naphthaline hydrogen compounds.

DUST EXPLOSIONS

IT has become well known that a wide variety of dusts will explode if ignited by flame or spark under favorable conditions, particularly where the right mixture of dust with air obtains. An explosion of hard rubber dust recently occurred in which eight men were killed and considerable property damage done. The Bureau of Chemistry has made an investigation of this accident which is discussed in detail in the April 27th number of *Chemical and Metallurgical Engineering* and the investigators take occasion to emphasize the following precautions to be taken in hard rubber grinding:

"1. The grinding department should be segregated from the remainder of the plant and if possible operated independently of other units.

"2. The building containing the grinding department should be of heavy framework with light walls and roof so as readily to permit the release of pressure from the building should an explosion occur. Large window area serves this purpose very well and the modern daylight construction is recommended.

"3. Good ventilation should be provided and where gases heavier than air are produced during the process the air should be drawn out of the room near the floor and fresh air admitted near the ceiling or roof.

"4. Where fine dust is produced during the process an efficient dust-collecting system should be installed. The old-style dust room, where large clouds of dust are in suspension, should be eliminated if possible or located at a safe distance from the main building. The dust should be collected as near as possible to the point of origin and conveyed through pipes with as few turns as possible to the collector, which should be located outside of the building or vented to the outside air. If sharp turns are necessary in the pipe line inside the building, it is often advisable to provide a vent at the bend leading to the outside air with a cap which will be blown off should any high pressure occur at this point. Drawing explosive dusts through a fan should be avoided if possible. A suction through the collector or an induced-air current is preferable.

"5. Special precautions must be taken to see that no metal enters the grinding machines. This is the only way to guard against ignition of dust by sparks struck in the machines. A vent leading directly from the machine to the outside air often assists in preventing a disastrous explosion by providing a direct means of escape for the primary explosion within the machine.

"6. In places where clouds of explosive dusts are produced electric lights should be enclosed in vapor-proof globes and properly guarded to prevent accidental breakage. All switches and fuses or electrical equipment in which sparks might be produced should be located in a separate room or at least enclosed in fireproof and dustproof boxes.

"7. Rules against smoking and carrying matches in sections of a plant where conditions are favorable for a dust explosion must be rigidly enforced and special attention given to the prevention of hot boxes on machinery operating in dusty atmospheres.

"8. Cleanliness is the best general precaution to adopt for the prevention of dust explosions. A disastrous dust explosion cannot occur in a clean plant, because the flames cannot propagate unless dust is present to be mixed with the air in sufficient quantity. From 0.02 to 0.04 oz. of dust per cu. ft. of air is usually sufficient to form an explosive mixture. The plant should be kept scrupulously clean, especially overhead structures where dust accumulations could be thrown into suspension in the air by a sudden jar or shock."

Steel Direct from the Ore

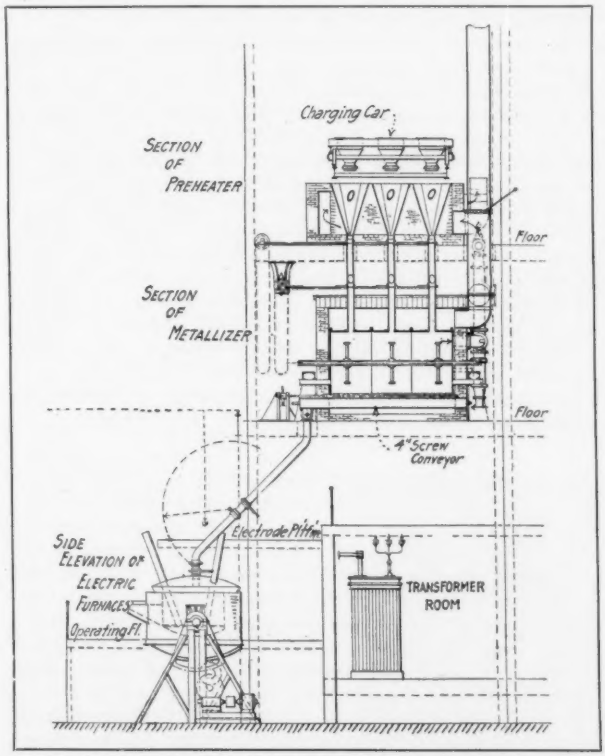
Recent Attempts at Producing Steel Without the Intervention of the Blast Furnace

By Edwin F. Cone

FREQUENTLY there have appeared in the public and technical press in the past rather sensational articles on the production of steel direct from iron ore. Within the last month or so this subject has again been brought to the front by a cablegram from France to the *New York Times* making striking claims for a new process of this nature, known as the Basset. It has elicited comment from metallurgists and technical papers and has created considerable interest.

At the outset it may be stated that thus far in the history of this movement none of the suggested processes has reached the successful commercial stage. This is not to say that some of them will not, for he is a rash prophet who predicts the failure of projects that now seem revolutionary.

In the first place it is well to explain what is meant by the term "steel direct from the ore." According to present world-wide practice, iron ore is first converted into pig iron in what is familiarly known as the blast furnace. This is initially an expensive apparatus costing several million dollars when installed on the present American scale; that is, a furnace which will produce 600 tons of pig iron per day.



SECTION OF THE METALLIZER THROUGH THE IRON ORE RETORTS AND THE MECHANISM FOR DELIVERING THE IRON SPONGE TO THE ELECTRIC FURNACES

In such a furnace the iron ore is mixed with lime stone and with a high grade of coke. The smelting operation by means of a blast of hot air under pressure converts the iron ore into iron; that is, the carbon of the coke eliminates or burns out the oxygen of the ore and the result is iron containing dissolved carbon to the extent of 3 to 4 per cent and other elements. This is the commercial pig iron of to-day as made in all large producing countries. After the first installation of the blast furnace, the process is not an expensive one. It depends of course on the ability to obtain a good coking coal within reasonable distance of the iron ore. This process has become firmly entrenched in America and Europe.

The dream of metallurgists and inventors has been to devise a process whereby the making of pig iron in a blast furnace could be eliminated and the ore converted directly into steel. To make steel by present practice, it is necessary to convert the blast furnace pig iron, in the cold or hot condition, into steel in a separate furnace. The plan as worked on by inventors has been to reduce the iron ore to iron in one apparatus and then to convert this iron into steel either in the same apparatus or in an additional furnace. The former is known as the one-step direct process and the other as the two-step direct process. The advantage of a successful direct process, aside from the expense, would be the doing away with the use of coke and the use in its stead of any grade of coal as a fuel. Such a successful process would make its use a great boon to such countries as Sweden, Norway, Canada and Brazil where the ores are plentiful and of high grade, but where there is very little coal suitable for blast furnace operations.

With this object in view there have been several processes of direct conversion put forth but none of them as yet successful commercially unless it be the French Basset process already referred to. The fault cannot be said to lie entirely in the process as devised. So much pig iron is cheaply made by the present blast furnace that this has tended to smother the success of the new ideas.

One of the less recent processes of a direct nature is the Jones, an American process. This has been characterized by one American electrochemist as "antiquated and imperfect" and that "to compare it with the Basset is like confounding night and day." The Jones process is a step process in that there is more than one step involved before steel is produced.

Another process, patented in the United States and in foreign countries in 1920, is the Lang. A description of this process appeared in *The Iron Age*, May 12, 1921. In this process ore is mixed with coal, both powdered, and the mixture placed in metal shells. These fall slowly down a long reverberatory furnace and the gases heat and reduce the ore in the shells which then fall into a special receptacle where the reduced iron, shell and all, is melted. The final purification is done in another furnace, probably electric. This process is being installed at a plant in Santa Cruz, Cal., by the Direct Process Steel Co., Inc. The future will reveal its practicability. In California coke is scarce and some such process as that or the electric is much desired.

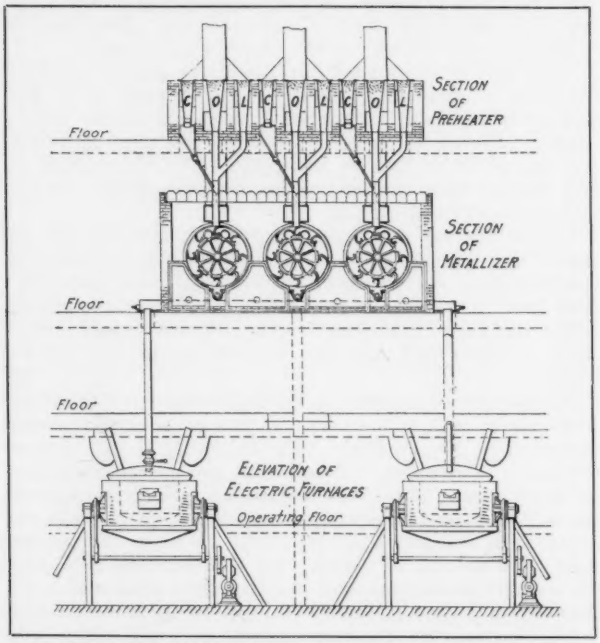
One of the latest, prior to the Basset, which American metallurgists have investigated, is the Bourcoud. This is a very elaborately calculated process for direct conversion in which large revolving cylinders, like cement kilns, are used where the theoretical amount of fuel and gases are brought in contact with the fine ore and, it is clamed, complete reduction is obtained. The reduced iron is then refined and converted into steel in electric furnaces. The process is completely described in a recent issue of *Iron and Steel* of Canada, but as far as known it has not been used anywhere commercially.

The Basset process, about which so much has been said recently, was first referred to in this country in *The Iron Age*, September 9, 1920, but details were lacking at that time. According to the reports from France which have recently been made public, this process uses powdered coal and iron ore mixed and the grade of coal need not be of the best. The oxygen necessary for ignition is introduced as a blast of hot air preheated to about 1,000 deg. cent. This heated air

is also mixed with powdered coal. The combined result of the combustion is stated to be a temperature far beyond the fusion point of the reduced metal and slag which, it is claimed, results in the product's being withdrawn from the furnace as molten steel. It is really a one-step process. Reports from Paris are that it is in successful commercial operation in France. An American electrochemist has said recently that "it does not seem likely that it will have general or extended application without considerable modification in practice."

Of interest at this time is a German opinion of the Basset process. At a meeting of the German Iron Masters' Association last winter an address was delivered by Doctor Wüst, director Kaizer-Wilhelm Institute for Iron Research at Düsseldorf, Germany, on the process of direct smelting of iron ore into steel. His remarks, as reported by the London *Ironmonger*, were as follows:

He traced the development of the various iron-making processes, and referred to the Basset direct smelting process, of which there has been so much talk lately and which claims to be able to produce iron 70 per cent cheaper than it can be made in the blast furnace, and to save 80 per cent in the cost of installing the plant. Dr. Wüst showed by temperature calculations that a revolving furnace under the Basset process could turn out only one-fifth of the iron produced by a blast



GENERAL ARRANGEMENT OF THE REDUCING FURNACE OF THREE RETORTS AND THE ELEVATION OF THE TWO ELECTRIC FURNACES

furnace of the small capacity in the same time, and declared that the new process was not at all likely to replace the present indirect method.

Our next door neighbors, the Canadians, claim credit for a direct process which has been known for some time in its earlier stages. It is the one developed by J. W. Moffat of Toronto, Canada, and originally introduced at the Moffat-Irving Steel Co. There for some years steel was made direct from ore in a small way, but it never developed on a large scale. Possibly expense of operation or the necessity for improvements were the reasons.

At any rate within the last year or two Mr. Moffat has decidedly changed his original methods and has developed a steel-direct-from-the-ore process which bears his name and which has been described in detail in several technical papers. The latest one appeared in *The Iron Age*, June 2, 1921, while others were published in *Iron and Steel of Canada* in October, 1920, and in the *Canadian Mining Journal*.

Briefly the Moffat process uses a special furnace called a metallizer in which the ore is reduced to metallic iron or iron sponge by the use of coal and lime, the three materials being pre-heated in a pre-heater. The metallizer contains a rabbling apparatus which keeps the material constantly agitated, lifting the ore particles and exposing them many times to the reducing gases. The metallizer product or iron sponge then falls down on an air-tight conveyor which delivers it to one of two electric furnaces where it is converted immediately into steel by refining out the impurities and adding such materials or alloys to make the kind of steel desired. The illustrations show quite clearly the Moffat process which is typical of most of these direct-from-the-ore steel schemes.

The whole question of a direct process revolves around two factors: the expense of the apparatus and its dependability, and the successful conversion of the reduced iron, or "iron sponge" so-called, into a refined product which can compete in quality as well as in price with the present processes. The great difficulty has been not only the expense of the apparatus for reducing the ore and its cost of upkeep, but the handling of the iron sponge. This material, when in the highly heated condition, resulting from the reducting operation, has an intense affinity for oxygen and tends to at once re-oxidize and become iron oxide or ore again. Unless this iron sponge is handled very quickly, no process can be a complete success. It is therefore necessary to await practical demonstrations of the Basset or any process on this particular point.

So marvelous have been scientific and metallurgical developments in the past seven or eight years, it is unwise to look with disfavor on any direct steel-making process. Less than ten years ago it was said that steel would not be made in electric furnaces in the United States on any large scale, and yet to-day this country leads the world in this industry. It is possible that a direct steel-making process may still be a commercial success, but it is surely a considerable distance in the future, for to supplant the present extensive blast furnace industry of the United States is a herculean task. There is also to be remembered that modern steel-making practice on a large scale involves the conversion direct into steel of molten pig iron from the blast furnace by the use of mixers, converters and open-hearth or electric furnaces. This results in quick production of large quantities of high grade steel. There is, therefore, considerable skepticism as to whether any direct process can produce quality steel in quantity.

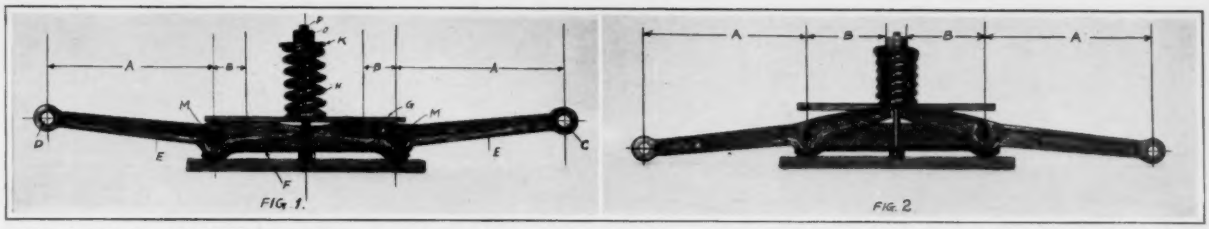
THE QUICKNESS OF RESPONSE OF CURRENT TO VOLTAGE IN A THERMIONIC TUBE

STEADY voltages were applied between the hot and cold electrodes of a thermionic tube, for intervals of time which could be varied from 0.00001 second to a minute or longer. The mean current during the interval was measured by the Wheatstone bridge, using a null ballistic type.

Two types of thermionic tube were employed, one at a comparatively high gas pressure, the other at a far higher degree of exhaustion. It is found that on applying the voltage the initial rise of current to its maximum is followed by a fall, the rate of which diminishes with time. In the tube at the high gas pressure the effect is considerable, and the final value of the current may be less than half the initial value. In the case of the tubes at lower gas pressure the fall, though sensible, is far less pronounced, say, three or four per cent.

An experiment is described showing that whatever the change of conditions causing the observed fall may prove to be, this fall is not attributable merely to the high temperature of the filament, but is conditional on the thermionic current being permitted to flow.

The results point to the practical conclusion that in order to avoid phase difference between current and applied voltage and consequent distortion at telephonic frequencies, of signals transmitted through a thermionic tube, the vacuum should be as high as possible.—D. Owen and R. M. Archer. *Proceedings of the Physical Society* of London, February 15, 1921.



FIGS. 1 AND 2. SUSPENSION DEVICE IN LIGHTLY LOADED (*LEFT*) AND HEAVILY LOADED (*RIGHT*) POSITIONS, ILLUSTRATING THE DIFFERENTIAL LEVER PRINCIPLE

Suspension Shock Absorber for Automobiles

New Construction Employing the Differential Lever Principle to Meet Variable Conditions

IN automobile construction one of the problems which calls for a solution as insistently as ever is the question of suspension. With higher rates of speeds, more variations in loading and the increasing use made of the springs to transmit the driving thrust as well as to take care of brake and torque reactions a demand has been created for better suspension, one which will satisfy present-day conditions.

A more intelligent study of the metallurgy of spring steel and the progress made in the heat treatment of springs in the past few years are factors which have brought the manufacture of springs to a very high state of perfection and yet in spite of the advances recorded in this direction one of the largest items of the upkeep during the life of the automobile is chargeable to the springs. This condition is largely due to the fact that the springs in use today are a compromise between two evils. If the strength of the spring be correctly proportioned to carry the empty or only partially loaded car it will be much too weak to sustain the full load. If on the other hand the strength of the spring be adequate to take care of the heaviest load it may be called upon to sustain it will be too unyielding for a lightly loaded car. To a certain extent this difficulty has been met by using a combination of springs of different strengths so arranged that the various units will come into action progressively, thus giving a graduated spring resistance. Of late the tendency has been for longer and more flexible springs giving a greater deflection, but owing to this greater movement of the vehicle body the liability to roll is largely increased.

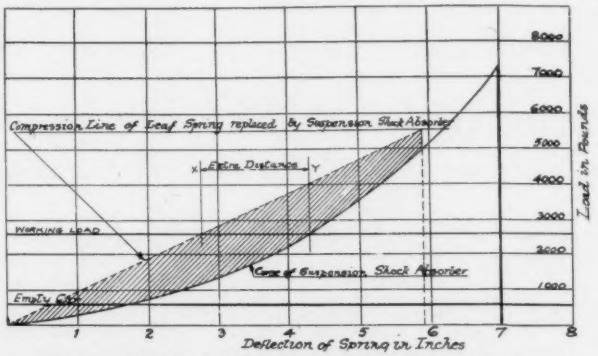
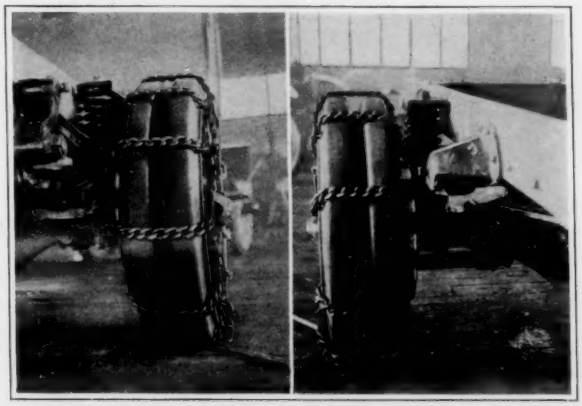


FIG. 3. GRAPHICAL COMPARISON BETWEEN THE IMPROVED SUSPENSION AND THE LEAF SPRING IT REPLACES



FIGS. 4 AND 5. SPRINGS USED FOR VEHICLES OF HEAVY LOAD CAPACITY

The great variety of shock absorbers, snubbers, bumpers auxiliary coil springs and spring oiling devices which are now on the market and find such a ready sale are in themselves an eloquent testimonial to the shortcomings of the leaf springs. The production of a suspension device which, contained in a single unit, would perform all the functions of these numerous accessories, be automatically adjustable to variations of loading and still be free from complications and readily repaired was the ideal kept in mind in the development of the suspension shock absorber described in this article.

A feature of interest in the design of the device is found in the application of the differential lever principle to secure the variable feature. The use of coil springs to supply the cushioning power also adds an added interest as their use in automobile construction without some extra device to dampen oscillations has not heretofore been found suitable. The leaf spring having friction between the leaves acts as a shock absorber and it is this quality together with its adaptability to fit in a restricted space which has made its use almost universal in road vehicle construction and preferred over the coil spring. The shock absorbing action found in the leaf spring is secured in the new device by the rolling and sliding action of a curve on a plane surface which makes the period of vibration dependent on the extent of the rolling and sliding between the coacting surfaces, thereby giving a fast period for small deflections and a slower period for greater deflections.

Reference to Fig. 1 shows the arrangement of the device in the lightly loaded position consisting of a casing "F" and two levers "E" pivoted to the casing through the pivotal points "M." The extreme ends of the lever at "C" and "D" are connected to the chassis in the usual manner while the underside of the casing resting on the axle at its central portion marked "J" is secured thereto in the usual manner. The inner end of the levers are in contact with the plate "G" which is held firmly in place by the compression in the coil spring "H." This plate is flanged at the sides for the purpose of adding stiffness and keeping a snug fit over the levers but for purposes of clearness these

have been omitted from the illustrations. Connection between the casing and the spring cap "K" is maintained by the bolt "P" which, bearing against the under face of the casing, passes between the levers and through the center of the coil spring and is threaded at the end to receive the nut "O." The weight of the car body causes the ends of the levers "C" and "D" to move downwardly, raising the inner end of the levers, displacing the plate "G" and compressing the coil spring. This action is transmitted through the long lever arm "A," while the force of the spring available to resist this movement acts through the comparatively short lever arm "B," giving a very yielding connection between the car body and axle. As the device is further compressed, however, the point of contact between lever and plate moves away from the fulcrum and increases the length of the lever arm "B," while arm "A" remains practically constant. The maximum travel is reached when the position of the lever as shown in Fig. 2 is assumed.

Fig. 3 is a graphical comparison between this improved suspension and the leaf spring which it replaces. The former is indicated on the diagram by the heavy curved line and the latter by the dotted line. Attention has already been directed to the advantage of flexibility under light loads and the extent to which this is carried out may be observed by the small angle which the curve makes with the horizontal line during the initial stages of the spring's deflection. This small inclination has the effect of lengthening the effective cushioning distance from free height to working normal load by the distance "XY," which eases the rebound movement very greatly. Another factor which eases the rebound movement is found in the reduction of the energy stored up in the spring when it is compressed by the amount indicated in the shaded area.

Figs. 1 and 2 show a design as used for ¾- and 1-ton trucks to replace a standard semi-elliptic. For heavier capacities two and three springs are used. Figs. 4 and 5 illustrate the application of the device to a 3-ton truck. Fig. 4 being a view looking from the rear of the truck and Fig. 5 a view looking at the front of the rear spring.

While the design shown in Figs. 1 and 2 is interchangeable with a semi-elliptic spring it was originally developed for use as a transverse suspension and as such has proved very successful counteracting the rolling tendency to a remarkable degree, reducing unsprung weight and permitting any desired deflection. When used in this connection the casing becomes the rear transverse member of the framing.

A summary of the advantages claimed for the new device and the points which have been kept in mind in the course of the development of the design are as follows:

The spring is flexible under light loads and relatively stiffer under heavy loads and live loads. The rebound is checked by reducing stored-up energy in spring to the minimum. It counteracts the tendency to roll. It transmits torque and thrust through the levers of the shock absorber. The moving parts are enclosed and lubricated. It serves as an effective shock absorber. All objectionable periodicity in the oscillation of the springs is damped out. All parts of the mechanism are accessible and easily removed and replaced. The unsprung weight is reduced by making the casing a portion of the frame. The parts entering into the manufacture of the shock absorber are standardized. The springs are adjustable to secure a given load at a certain deflection by turning one or two nuts.

Picric Acid as a Blasting Agent*

Finding Industrial Uses for Stores of Military Picric Acid Accumulated for War Purposes

By C. E. Munroe, Spencer P. Howell

Chief Explosives Chemist and Explosives Engineer, respectively, of the Bureau of Mines

AS in the case of TNT previously presented[1], this report presents the results of an investigation to discover the safest and best way of utilizing picric acid for industrial blasting purposes.

The investigation was undertaken solely to aid in the salvage of the surplus picric acid accumulated for war uses and released by the declaration of the armistice. No funds were available nor have any been appropriated with which to defray the expense of converting this picric acid into any other form or to prepare any explosive mixture from it. The sole problem was to find appropriate uses for this military picric acid in existing needs and to show that it can be efficiently used in carrying out essential civil projects.

It is not intended by this publication to promote the use of picric acid as an industrial explosive further than is necessary for the proper utilization of this surplus. On the contrary, the authors believe that picric acid by itself is unlikely to come into general use as an industrial explosive, chiefly because of its cost but also, as shown by the clouds of smoke it emits on explosion and the nature of the reactions it undergoes, because we do not obtain from it its highest efficiency. As demonstrated in its previous use in Joveite, better results and higher efficiencies may be obtained by mixing picric acid in proper proportions with sodium nitrate or ammonium nitrate more completely to oxidize the picric acid, and another nitro-substitution compound, such as nitronaphthalenes, with which to desensitize and waterproof the composition formed. By such admixture not only may the energy resident in the picric acid be more fully utilized but the cost of the resulting blasting explosive should be considerably less than that of picric acid.

Some quite serious accidents have occurred during the manufacture of picric acid and some in transportation, but in the accidents in transportation, other explosives being also involved, it has been difficult to determine the degree of responsibility of picric acid for such accidents. As later shown, picric acid is very stable and, when compared with other explosives, is not very sensitive to friction, to impact, to shock, or to ignition. In fact, as compared with the majority of explosives in common use, it may be regarded as a quite safe explosive. Marshall,[2] a well-recognized authority, says it "is nearly as insensitive as black powder," which refers to its insensitiveness to impact or friction but not to sparks or flame.

The gravest menace in its use arises from its tendency, when moist, to form picrates, for many of these are quite sensitive to friction, impact, and heat. They ignite and detonate picric acid with which they are in contact. Safety lies in keeping the picric acid away from picrates, and in so protecting it from contact with moisture and metals or metallic compounds that picrates cannot be formed from it.

But even when in the safest condition dry picric acid is an explosive, and like all other substances possessing explosive properties it should be handled, transported, stored and used with special care and surrounded by safeguards.

Since absolutely dry substances do not exist except under special rare conditions, the term *dry picric acid* as used in this publication means picric acid containing not more than two-tenths of one per cent of moisture.[3]

GENERAL CHARACTERISTICS

Picric acid appears as a highly crystalline powder having a lemon yellow color. This is the color required in the speci-

*Abstracted from a report (Serial No. 2243) of the U. S. Bureau of Mines.

[1]TNT as a Blasting Explosive, by Charles E. Munroe and Spencer P. Howell, Department Circular 94, United States Department of Agriculture.

[2]Marshall, Arthur, "Explosives," Vol. 1, 1917, p. 50.

[3]This definition is subject to revision as further information is obtained from demonstrations in the field.

fications of the U. S. War Department, but as manufactured, owing probably to the components in the water at the factory, it may be orange colored. Pure picric acid melts at 122.5° cent. (252.5.° fahr.). The War Department specifications require that is solidifying point shall not be lower than 120° cent. (248° fahr.). Since picric acid is found not to ignite until after it has become melted, its ignition point must be above 122.5° cent. The War Department specifications further require that the picric acid supplied to the department shall be of such degree of fineness that it shall pass through a 12-mesh screen having openings of 0.058 inch and wire of 0.025 inch diameter. The powder is free running and dusty, hence much care must be taken in drying, packing and handling it to avoid the forming of dust clouds and to prevent accumulations of picric acid dust about the working place. It stains the skin a clear yellow color where it comes in contact with the skin. This stain is very firmly fixed, but disappears after a time; and is not visible by gas light. Picric acid has an intensely bitter taste.

SOLUBILITY OF PICRIC ACID

According to Findlay, water at 15° cent. (59° fahr.) dissolves 1.16 per cent of picric acid and at 100° cent. (212° fahr.) 6.33 per cent. As compared with sugar, common salt, and many other well-known substances, picric acid is not a very soluble substance, yet it is decidedly more soluble in water than TNT is. It is, therefore, more hygroscopic than TNT, more prone to take up moisture from the atmosphere, and thus requires a larger measure of protection from the atmosphere than TNT does.

Picric acid has a high tinctorial power, for a very small weight of it will color a large weight of water or other substances. It is reported that one part of it will color 100,000 parts of water in which it is dissolved a distinctly visible yellow color. Many of the picrates are also quite soluble and also give a marked yellow to orange color to the solution. Naturally, when an explosive possesses such high coloring power as picric acid and picrates do, the ground and objects close to and round about the place where a charge is fired are likely to be stained by it, especially if the ground and objects are moist. Where explosives containing picric acid, such as Joveite, or picrates, have been fired in blasting such staining has been observed, and the users have concluded from this that a large part of the explosive failed to explode and that there had been a great waste of explosive. Bearing in mind that, as stated above, picric acid and picrates have a high tinctorial power it is conclusive that a very small quantity of the explosive would stain quite an extended surface. As a fact most of the staining produced in the use of such explosives in blasting was due to carelessness in handling the explosive by which some was spilled about the firing ground. When picric acid is supplied in properly made cartridges and these are properly handled neither the person using them nor the objects about the firing ground should be materially stained.

PACKAGES

Military picric acid, as offered for use in industrial operations, is packed in granular crystalline form, wet with ten to twenty per cent of water, either in boxes or in barrels. The boxes are of lock-cornered construction lined with two thicknesses of waxed or paraffined paper. In opening the boxes, if force is necessary, the covers should be pried off with wooden wedges.

Wet picric acid has also been received at the explosive experiment station in well-constructed tight barrels, unlined, containing 460 pounds of wet picric acid, and having a gross weight of 527 pounds. This type of container is permissible only if the picric acid is wet and shipped as an inflammable solid.

It is to be noted that, while wet picric acid may be shipped as an inflammable solid, redipped paraffined paper cartridges of dry picric acid must be shipped as a high explosive, and that the boxes must comply with I.C.C. 14.

The use of dry picric acid for industrial purposes should be restricted in all cases to its use in redipped paraffined paper cartridges, and it should never be used loose in bulk, for the reasons given above.

When dry picric acid is packed in cartridges, the apparent specific gravity of the charges may vary from 0.85 to 0.95, though the latter density is only obtained when the dry picric is tamped very hard by hand. On the other hand, 40 per cent straight nitroglycerin dynamite when so packed has an apparent specific gravity ranging from 1.15 to 1.34. Evidently for equal weights, dry picric acid cartridges will be more bulky than dynamite cartridges. As a consequence, greater diameter or greater length of charge must be used for dry picric acid charges than for dynamite charges of equal weight. This presents an advantage for the dynamite over dry picric acid.

PICRIC ACID AS A POISON

Unlike TNT, picric acid is but remotely poisonous. Referring to its use in beer as a substitute for hops Allen[4] states that rabbits and dogs have been killed by doses of it varying from 0.06 to 0.6 grams (0.9 to 9 grains). Ehrenfried[5] states that there is no fatal case of picric acid poisoning on record, but 15 to 30 grains are sufficient to cause toxic symptoms. Koelsch,[6] writing of experiences during the Great War, says that in loading plants where picric acid was pressed in forms to be loaded into fuses or into shell, or melted and cast into shell, the operators were exposed to picric acid dust and fumes but that the physiological effects produced on them was in most cases negligible. Neither acute nor chronic poisoning was observed. Some supersensitive workers experienced irritation in throat, nose and eyes, loss of appetite, and pains in legs and head, but no special precautions were deemed necessary except the transfer of these sensitive workers to other employment. In a wide experience with picric acid by the authors (extending for one of us over a term of 45 years), covering the manufacture of picric acid, many picrates, and picric powders, the use of picric acid in shell loading, the use of picric acid alone and of picric powders in blasting in the open, in quarries and in mines, and the analyzing and testing of picric acid, picrates and picric powders where many men have been employed in these operations, we have never encountered an instance of poisoning from it. We feel justified in expressing the belief that this menace is very remote.

IGNITION OF PICRIC ACID

Picric acid is ignited by flame or sufficient exposure to heat. It is very insensitive to ignition by friction or sparks. When heated in mass it melts before it ignites and therefore if a hot body, such as a heated steel ball, is brought in contact with a mass of picric acid, unless the mass of the ball is quite large or the ball is very highly heated, the heat of the ball may be, and, in instances, has been, expended in melting the picric acid without igniting it. Burning picric acid either unconfined or when confined in packing cases, or boxes, has been extinguished by drenching it with water, especially from automatic extinguishers. Hence, factories, drying houses, packing houses and magazines containing picric acid will receive a large measure of protection from the installation of automatic fire extinguishers in them. Picric acid in burning emits fumes which produce a peculiar bitter sensation in the back of the throat. This is a most delicate and characteristic test. The smoke is black but not so dense as that from burning TNT. As regards fire the most danger is to be apprehended from picric acid dust, for, in common with all combustible dusts, picric acid dust forms explosive mixtures with air, and as picric acid is more readily ignited than coal, corn, wheat, starch and many other inflammable and combustible dusts whose mixtures with air have repeatedly, on ignition,

[4] Allan, A. H., "Commercial Organic Analysis," 1900, Vol. 3, pt. 1, p. 119.

[5] U. S. Dispensatory, 20th ed., p. 1165.

[6] Koelsch, F., "Toxicity of Picric Acid." Z. gas. Schiess Sprengstoffw., 1920, Vol. 15, pp. 104-107.

SOLID WHITE OAK STUMP 3 FEET 6 INCHES IN DIAMETER WHICH WAS BLASTED IN TEST NO. 2

given rise to explosions, the picric acid dust is more dangerous than coal and cereal dusts. Hence in factories and packing houses extreme care should be taken to prevent dust from arising, and also to prevent its accumulating on the tables, walls, rafters, ledges or any part of the building, and especially on any part of the heater system. In these buildings good housekeeping is especially essential.

Many of the more commonly known picrates, especially iron picrate, are quite easily ignited by friction, percussion and heat. Iron picrate has often been formed on iron water pipes and steam pipes, tools and vessels in works where picric acid was made or used. There are many records of "a flash" having followed when a mechanic, to make necessary repairs or changes, started to work, in the ordinary manner, on these pipes or vessels.

EXPLOSION OF PICRIC ACID

Although, following Turpin's development of melinite, picric acid has been melted in many thousand instances and cast into shell, and, although picric acid has repeatedly been melted, by direct contact of the crucible containing it with an open fire, without causing the picric acid to explode, yet, in Berthelot's well-known method of demonstrating the explosibility of chemical substances, picric acid does explode when a small portion of it is dropped into a glass test tube which has previously been heated to a high temperature.

Explosions have occurred in picric acid factories following the breaking out of fires in such factories, though in some instances quantities of picric acid exceeding 2,000 pounds, and, in one instance as much as 5,500 pounds, burned away without an explosion taking place. It has been demonstrated that where basic metallic oxides, such as the lead oxide, known as litharge, are present with picric acid violent explosions were readily produced by heating them.

Picric acid, when loosely packed, may be detonated by a No. 6 detonator provided the detonator is so inserted in the mass that it is in close contact with the picric acid and that the latter is perfectly dry. It is, however, bad practice in blasting to use that weakest strength detonator which has been found to detonate an explosive. Under the most careful management a "failure to fire" may occur which might not occur if a "stronger" detonator were used. "Failure to fire" usually creates a dangerous situation. The difference in cost between a No. 6 and a No. 8 detonator is less than two cents. While picric acid is more sensitive to detonation than TNT is, it is advised that No. 8 detonators be used for detonating picric acid, since for an expenditure of less than two cents a large measure of certainty in firing is assured and "misfires," which often are quite costly, become practically unlikely.[7]

GASEOUS PRODUCTS OF DETONATION

An explosion is produced by means of picric acid when fired by itself owing to the fact that the mass of picric acid in the solid state, is rapidly decomposed and converted into a mixture of highly heated gases. The temperature realized, according to Brunswig (Brunswig, H. "Explosives." Translated by Charles E. Munroe and Alton L. Kibler. New York, 1912, p. 152), is 2430° cent. (4406° fahr.), though this, while always high, must vary somewhat with the conditions under which the explosion takes place. The explosion may, according to circumstances, take the form of a simple explosion such as always characterizes the explosion of black gunpowder or of a detonation such as always characterizes the explosion of mercury fulminate. The difference between the two forms of explosion lies chiefly in the speed which according to Brunswig (Brunswig, H. Work cited, p. 98) was found to be at the rate of 300 meters (984.25 feet), per second for gunpowder and 3,920 meters (12,861 feet) per second for fulminate of mercury.

Picric acid may explode (1) by simple explosion and be converted into carbon dioxide, carbon monoxide, hydrogen and nitrogen which appears as gases, and free carbon, which appears as soot and imparts a dark to gray color to the "smoke"; or it may explode (2) by detonation giving carbon monoxide water, hydrogen and nitrogen, all in the gaseous state; or its explosion may take the form of a partial detonation or a detonation of a low order (3) yielding some carbon dioxide as in (1) and less water than in (2).

Carbon monoxide, hydrogen and methane are all easily ignited and combustible gases and can form explosive mixtures with air. Carbon monoxide is an extremely poisonous substance, and it is given off in large quantities by picric acid whatever kind of explosion it undergoes. Hence picric acid, by itself, should never be used as an explosive in underground mines, or in close places where the gaseous products are confined and held, for they might give rise to accidents from gas explosions and especially from poisoning. Where ventilation is complete, as in the open air, and especially when operators and observers stand to the windward of a shot there is

[7]This statement is amplified in "Dangers in Using Low-grade Foreign Detonators," by Charles E. Munroe, Reports of Investigations, Bureau of Mines, Serial N. 2226, March, 1921.

little likelihood that anyone will be affected by the gaseous products or fumes.

Picric acid has been shown by tests to be relatively insensitive to explosion by friction or by percussion, and certainly to be less sensitive to these influences than industrial explosives which have been in quite general use.

RELATIVE EFFICIENCY

In determining the relative efficiencies of explosives in use, the Bureau of Mines has long employed the "unit deflective charge," and the "rate of detonation" as criteria. The unit deflective charge is ascertained by exploding a known weight of the explosive in the ballistic pendulum and this term, "unit deflective charge," is defined as "that weight of an explosive which will swing the ballistic pendulum the same distance as one-half pound of 40 per cent straight nitroglycerine dynamite." It appears that explosives of which the unit deflective charge is smaller have the greater propulsive capacity; hence, the unit deflective charge is considered a measure of the ability of an explosive to dislodge and bring down material in which it is exploded. Picric acid is stronger by 18 per cent when so measured than 40 per cent straight nitroglycerin dynamite.

TRAUZL LEAD-BLOCK TEST

The "trauzl lead-block test" measures the comparative disruptive effect of different explosives fired in charges of equal weights, under moderate confinement, in small cylindrical bore holes of equal volumes and dimensions, formed in carefully prepared large lead blocks, and measuring the resulting increase in volume of the cavity in the lead block.

The results of tests of dry picric acid and other explosives when fired in cavities in lead blocks by the Trauzl method as practiced by the Bureau of Mines, are given in the following tabulation, in terms of the increase in volume of the cavities in each case and these results are compared with one another by taking 40 per cent "straight" nitroglycerin dynamite as a standard with a value of 100 per cent:

Table 1.—Trauzl Lead Block Expansion of Nine Explosives

Explosive	Expansion in c.c.	Per cent
Blasting gelatin	400	149.8
60% "straight" dynamite.....	321	120.2
Picric acid	316	118.4
Granulated TNT	302	113.1
50% "straight" dynamite	281	105.2
40% "straight" dynamite	267	100.0
40% ammonia dynamite	202	75.7
40% gelatin dynamite	195	73.0
Black blasting powder	28	10.5

CHARGING BORE HOLES

Picric acid should be charged into bore holes, primed, tamped, and stemmed in the approved manner customarily followed in the use of cartridges of high explosives in blasting, special care being taken in charging wet holes not to tear or break the cartridge case or wrapper while loading the cartridge into the hole or while tamping it, for water rapidly reduces the sensitiveness of picric acid to detonation.

To secure the most efficient results a sufficient quantity of stemming should be used and this should be well tamped. There is no doubt that much explosive is wasted in blasting owing to the failure to observe these instructions. The great economy effected in the use of explosives in mines by following these instructions has been thoroughly shown by Snelling and Hall (Snelling, W. O., and Hall, Clarence, "The Effect of Stemming on the Efficiency of Explosives," Bureau of Mines, Technical Paper 17).

Picric acid may be used in chambering holes, for subsequent charging with black blasting powder, just as dynamite is used. It may also be used in "adobeying" or "mud-capping" bowlders by placing the charge on the bowlder and covering it with moist clay, earth or sand by which to confine the charge.

When picric acid shots are fired, if the detonation is complete, there will be produced a dark bluish-gray smoke, the unstemmed shots usually giving a darker smoke than the stemmed shots. In incomplete detonation the smoke has a greenish-yellow color and a deposit of undecomposed explosive may be formed on surrounding objects.

Instances arise where in an emergency it is desired to remove obstructions in blast furnaces, such as salamanders, or to break up slag piles while the material is still hot. On account of its high initial explosion temperature and great explosive energy picric acid appears, among explosives, to be the one best adapted to such use, especially when of high density, for experiment has shown that the rate of detonation of picric acid increases with the density, and at very high densities approaches the unusually high rate of 8,000 meters per second. It is recommended that when so used the temperature of the bore hole should not exceed 76.7° cent. (170° fahr.) and that the shot should be surrounded with special safeguards, and the charge be fired promptly.

PRACTICAL DEMONSTRATIONS IN THE FIELD

The practical value of picric acid for general blasting purposes, other than in underground mining, has been demonstrated by field tests in stump blasting and bowlder breaking

THE BLAST IN TEST NO. 2

made on the grounds of the Bureau of Mines explosives experiment station at Bruceton, Pennsylvania, by J. E. Tiffany, assistant explosives engineer.

For the purpose of these tests a quantity of picric acid was dried and found to contain 0.38 per cent of moisture. It was loaded in 1¼- by 8-inch paraffined paper shells with great ease. Each cartridge weighed about 170 grams (6 ounces).

The stumps were all rooted in clay and the surface of the ground was on a slope dipping to the north in the case of the first two stumps and almost level for the third stump. The holes were about 1½ inch in diameter at the bottom and were in some cases over 2 inches at the top. They were in every case put down in the ground under the stump or lateral roots by means of a pointed steel bar. The cartridges were loaded in the holes and the primer placed on top with a No. 6 electric detonator centrally inserted in the primer. A wad of stiff paper was placed on top of each charge used in stump blasting and the hole was then tamped with clay stemming to the top of the hole. The blasts were fired by means of a push-down multiple hole blasting machine, connected to duplex

lead wires and in the case of the stump blasts the electric detonators were connected for each stump in series, the two free legs being connected to the duplex leading wires, while in the adobe shot the legs of the one electric detonator used was connected to the duplex leading wires.

Test 1.—A solid white oak stump, which was two feet in diameter and standing about 2½ feet out of the ground was removed by firing picric acid under it. Two holes were bored, each 3½ feet long, of which one was in the ground on the higher side, and the other on the lower side. Both holes were so inclined that the bottom of each hole was about under the center of the stump. The upper hole was loaded with two cartridges of picric acid and one-half cartridge primed with a No. 6 electric detonator placed last in the hole. The lower hole was charged in a similar manner using one cartridge less. The six cartridges thus used weighed about 2¼ pounds. As a result of the explosion there was a muffled report, accompanied by a cloud of smoke of a light gray color. The stump was split into several small pieces and a small crater was left in the ground.

Test 2.—A solid white oak stump 3 feet 6 inches in diameter was blasted. There were 3 well defined lateral roots to this stump each of them having smaller branch roots. On the upper side the stump stood about 2 feet above the ground. Four 4-ft. holes were located and put down in the ground in such a direction that when loaded there were 5 pounds of picric acid cartridges directly under the main part of the stump, while 6 holes were placed under the lateral roots in which a total of 4½ pounds of picric acid cartridges were loaded. Some of these holes were loaded with one cartridge while others had as much as two cartridges. The holes were all very wet in the bottom so that a 1¼- by 8-inch paraffined paper shell was cut across into halves, each one of which was almost filled with sawdust and its upper end closed with a small wad of newspaper. The latter end was inserted in the hole first. Each hole had such a sawdust cartridge placed in it, the purpose in mind being that the water in the hole would be absorbed by the sawdust after soaking through the newspaper, and thus prevent the moistening of the explosive. The report of the explosion was somewhat muffled, the smoke was of a light gray color.

As a result of the blast the main part of the stump was split into about three main fragments of equal size which were thrown in the air, one piece of which landed about 45 feet away while the other two pieces were found close to each other about twenty feet away but in another direction.

The crater remaining after the blast was about 10 feet in diameter and about 4 feet deep.

Test 3.—A solid walnut stump, 2 feet in diameter, was blasted. Three holes were bored in the ground inclined toward each other so that the bottoms of the holes were under the stump. The holes were about 3 feet deep and were loaded with a total of 3 pounds of picric acid made up in paraffined paper shell. Two of the holes were each loaded with two cartridges with primer on top consisting of a half cartridge in which a No. 6 electric detonator was centrally inserted while the third hole was loaded with 3 of the cartridges and a primer similar to that used in other holes.

The blast split the stump in three main pieces, two of which were afterward found 20 to 45 feet, respectively, from the original position of the stump. One piece fell back in the crater left by the removal of the stump.

Test 4.—A sandstone bowlder 13 inches by 23 inches by 66 inches was selected for the purpose of demonstrating the suitability of picric acid for breaking bowlders. The bowlder was resting on solid rock. Four picric acid cartridges were laid on the center rock, in pairs, the ends of one pair touching the ends of the other pair. One of the four cartridges had inserted in it a No. 6 electric detonator. The cartridges were then covered with clay to a thickness of about 3 inches and fired. The bowlder was shattered throughout its entire mass as a result of the explosion of one and one-half pounds of picric acid. Fifty per cent of the bowlder was broken into fragments of about two-inch size.

CONCLUSIONS

The results of the above described blasts in removing stumps and in breaking a bowlder by means of an adobe shot using picric acid having a moisture content of 0.38 per cent and loaded in 1¼- by 8-inch paraffined paper shells show that picric acid is suitable for use in work similar to that described in this report. Especial attention is directed to the successful firing of picric acid in very wet boreholes in Test No. 2, and that special precautions were used to protect the explosive from water in the bore hole.

Arrangements have been made for a coöperative investigation of the use of picric acid as a blasting agent by the College of Agriculture of the University of Wisconsin, analogous to that made on TNT, and described in Department Circular No. 94 of the Department of Agriculture.

MANUFACTURE OF RESEARCH CHEMICALS

THE University of Wisconsin announces an experiment for this summer during which eight advanced students will be given a course during which they will be paid for their work while producing research chemicals needed in the various scientific departments of the university. The most promising students will be selected for this work with a view to giving them intensive training in organic chemical preparations on a large scale. The various departments of the university have been asked to make known their needs so that a program of work may be outlined.

CRATER ABOUT 10 FEET IN DIAMETER AND 4 FEET DEEP RESULTING FROM TEST NO. 2

Sounds of Meteorological Origin*

Thundering, Roaring, Howling, Shrieking, Humming, Murmuring and Whispering of Nature

By W. J. Humphreys, C.E., Ph.D.

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PROBABLY all, or nearly all, who have experienced a cold winter are familiar with the cheery cry of the snow as it is pressed against a hard surface by the steel tire of a wagon, for instance, or even upon a pavement by the heels of one's boots.

When the temperature is just a little below the freezing point, the snow, then in fine condition for snowballing, does not creak, and the track of the wheel is marked by a strip of more or less compact ice. On the other hand, when it is so cold that the snow will not ball, its voice is loud, and the track left by the wheel is now marked, not by a strip of compact ice, but by a trail of crushed and powdered crystals.

In the first case, that is, when the temperature is only a little below freezing, the snow crystals obviously melt, to a greater or less extent, as a result of the pressure to which they are subjected, and undergo regelation as soon as the pressure is removed. The yielding is gentle and progressive through melting and flowing, and not of that abrupt nature essential to the production of sound.

In the second case, however, or when the snow is too cold to melt under the pressure applied, its yieldings and readjustments are abrupt and jerky incident to the crushing of the crystals and their slippage in a dry condition over each other. It is these abrupt yieldings, these sudden breaks and slips of its dry crystals, that produce the familiar cold-weather creak and cry of the snow.

THUNDER

Cause.—Thunder, one of the most familiar and certainly the most impressive of all meteorological sounds, has been "explained" in many ridiculous ways, but generally, perhaps, just accepted. Any careful observation, however, will soon show that thunder is associated with lightning, and that the lightning flash always precedes the thunder. Clearly, then, thunder is somehow caused by lightning.

Now, it is known that sudden and intense heating, and molecular dissociation occur along the path of a lightning discharge. Hence a corresponding abrupt expansion, simulating a violent explosion, also occurs along this path; and this expansion in turn produces a compression wave in the surrounding atmosphere that travels outward exactly as would any other sound wave.

Musical Thunder.—It occasionally happens, when one is near the path of a lightning flash, that the thunder heard begins with a musical note. This is due to the fact that some lightning discharges—the flickering type—consist of a series of rapid flashes that occasionally are nearly enough regular, and of such frequency, as to produce a quasi-musical note.

Duration.—The long continuation of thunder is due, chiefly, to the great difference in the distances of the nearest and farthest points of the lightning path from the observer. If this difference is five miles, as it occasionally is, the duration of the thunder, owing to this cause alone, is roughly 24 seconds.

The duration of thunder is also prolonged by reflection. Occasionally the echo prolongation is very pronounced, but it is everywhere variable and uncertain.

Rumbling.—The great variations in the intensity of thunder that constitute its characteristic rumbling are due:

(*a*) To crookedness of path. The thunder starts from all parts of the discharge path simultaneously, or practically so, and thus the observer hears simultaneously the thunder from the whole of any portion of the path that happens to be at a constant distance from him. Now, as the path usually is very crooked, it generally happens that many portions of it are at one or another nearly constant distance from any given point. Hence, almost every peal of thunder is of irregular intensity, and as no two lightning paths are alike so also each peal of thunder differs from every other.

(*b*) To the sequence of discharges. Obviously, when a number of discharges follow each other in rapid succession—when the lightning is flickering—there is likely to be more or less interference between the several sound pulses resulting now in partial neutralization and again in reinforcement, the whole merging into an irregular rumble.

(*c*) To reflection. Reflection by mountains, hills and other objects may occasionally be effective in prolonging the noise of thunder and accentuating its rumble. However, mountains and hills are not nearly so essential to the rumble of thunder as occasionally they are said to be, for the rumble of the thunder, whether in the valley ,on the plain or on the peak, is substantially the same.

Distance Heard.—Thunder seldom is heard more than 15 miles. This is much less than the distance to which cannon are sometimes heard. The circumstances in the two cases, however, are radically different. Thus, the sound energy from the cannon is relatively concentrated since it all starts from a single point and spreads out in a hemispherical shell, whereas, that of thunder starts, not from a single point, but from a crooked line often miles long. Furthermore, cannon often are fired when the surface air in which the firing occurs, is very still and otherwise in the best state for long transmissions of sound. Thunder, on the other hand, seldom occurs except when the winds are turbulent and the general conditions very adverse to sound propagation. Finally, the density of the air is greater at the cannon than along the lightning path, and hence its sound energy per unit volume, other things being equal, is also correspondingly greater in the former than in the latter case.

BRONTIDES

From time immemorial low, rumbling, thunder-like noises (brontides, *mistpoeffers*, "Barisal guns," etc), of short duration, and that certainly are not thunder, for they often occur when the sky is clear, have been heard in many parts of the world, both singly and in irregular series. They appear to come from a distance, but of uncertain direction, and are most frequent in actively seismic regions.

Apparently, then, the true brontides (many other sounds have often been mistakenly reported as brontides) are only the rumblings of earthquakes too feeble for registration or other than aural detection. And this inference is strengthened, if not indeed confirmed, by the fact that earthquake adjustments have been known to occur in a long irregular series of shocks that became feebler and feebler until only the characteristic low rumbles (then properly called brontides) remained, as presumable evidence of their passage.

HOWLING OF THE WIND

One of the compensations for being snowbound on a windy day is the pleasure of listening to the well-known howling of the wind as it sweeps by the chimneys and over the gables, and wondering where it gets its many voices, or, indeed, any voice at all. Nor is the wonderment yet over, for the problem of the howling of the wind has never been completely solved, at least not in the fullness of all the differential equations that tell the whole story. This much, however, is known: the howling, like the other æolian sounds discussed below, is due to eddy motions in the atmosphere immediately beyond the obstructing object. There is no resonance or other organ-

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pipe action, for the change from one pitch to another is not by jumps, as it is in all pipes, but gradual.

Let the direction of the wind make an appreciable angle with the roof and let the latter either project a little beyond the gable wall or, at least, come up flush with it. Under these conditions the wind will have its maximum velocity as it leaves the roof, and there in only a comparatively thin sheet. This sheet in turn, immediately on escaping the roof, drags along, through viscosity, some of the air just beneath it, and is itself slightly deflected in the direction of the consequent pull. In this way an abrupt change in the direction of flow is produced at the edge of the roof and hence an eddy will immediately start at that place. One effect of such an eddy, since it enters the current from relatively still air, is to decrease slightly the velocity of that current. It is quickly carried on, however, and the eddy-forming conditions are thereby renewed. In this general manner, presumably, eddy after eddy is formed at the edge of the roof with such frequency and such approach to regularity as to produce a more or less musical note.

These sounds generally are much better heard indoors than out. This is largely, if not wholly, because one is there far less disturbed by the innumerable other outdoor noises, especially the continuous and annoying whisper of the wind right in one's ears—also an eddy effect.

HUMMING OF WIRES

Few things, perhaps, have been more absurdly "explained" than has the well-known humming of telegraph and telephone wires, and that in spite of the fact that the correct explanation has long been at hand.

It was shown by Strouhal[1] that wind normal to a cylinder, such as a stretched wire, produces æolian tones even when the cylinder itself takes no part in the vibration; that the pitch of the note thus produced, independent alike of the material, length, and tension of the wire, varies directly as the speed, u, of the wind and inversely as the diameter, d, of the obstructing rod; and that the number, n, of such vibrations per second is given, approximately, by the equation

$$n = .185\ u/d$$

the units being the centimeter and second.

Whenever the tone thus produced coincides with one of the proper tones (fundamental or a harmonic) of the wire, the wire itself, if suitably supported, then vigorously vibrates, normal to the direction of the wind, and thereby increases the loudness and also holds the pitch fixed over a considerable range of wind velocity. The sound in question, however, that is, the humming of telegraph and telephone wires, is not due to the elasticity of the wires (the pitch changes gradually with wind velocity and not from harmonic to harmonic), but to the instability of the vortex sheets their obstruction introduces into the air as it rushes by them. This obvious and, indeed, unavoidable deduction from Strouhal's experiments, just referred to, is abundantly confirmed by cinema photographs of water eddies, due to flow past a cylinder, made at the National Physical Laboratory. Vortex whirls developed at regular intervals, alternately to the right and left of the interfering cylinder, while the eddy mass vibrated from side to side in the same period.

The complete mathematical analysis of these and similar vortices, giving the deduction of Strouhal's rules, and many others, would be both interesting and valuable, but it appears that this important problem has not yet been fully solved. Much progress, however, toward this solution, has been made by v. Kármán[2] and by v. Kármán and Rubach,[3] who have shown that evenly spaced vortices alternately on opposite sides is a stable arrangement, and the only one.

It is well known that the humming of telegraph and telephone wires is loudest when the wires are tightly stretched, as they generally are during cold weather. This appears to be because the eddies thus produced in the wind vary the tension on the wire, and rapidly the more so the tighter, or straighter, it becomes. Now these variations of tension are transmitted to the posts which in turn act as sounding boards, analogous to the sounding board of a piano, and hence largely increase the volume of the sound, whatever its pitch.

WHISPERING OF TREES

From the experiments of Strouhal, above referred to, it is evident that pine needles, bare twigs, and even the branches of trees, must all produce æolian notes—that trees must have voices, even voices that are characteristic of the species. And they do. The muffled plaint of the oak at the wintry blast, for instance, has but little in common with the sibilant sigh of the pine. And the reason is obvious; the twigs and branches of the one, because relatively large and of many sizes, produce a multitude of low tones, while the innumerable fine needles of the other give a smaller range of high-pitched notes.

It may be granted that, as shown by experiment, each twig and other similar obstacle in the wind must produce an æolian note. But how, one must ask, do a multitude of such notes blend together—how are the pitch and loudness of the resultant related to the like properties of the constituents?

[*The author here gives a mathematical demonstration which we omit, and arrives at the following conclusions.*—EDITOR.]

From the above two laws, namely (1) that the pitch of a composite note is the approximate average of those of its constituents, and (2) that the mean intensity is the sum of the individual intensities, it appears (*a*) that the pitch of the æolian whisper of a tree is essentially that of its average twig, or needle, if the tree be a pine, and (*b*) that though the note of the twig may be inaudible, even at close range, the tree may often be heard some distance away.

Just as the æolian whispers of the myriads of needles on a single pine tree, or of the numerous twigs on an oak, for example, blend into a whisper of the same average pitch but vastly greater volume, so too the whisperings of a great many individual trees merge into the well-known murmur of the forest.

ROARING OF THE MOUNTAIN

When a mountain well wooded along and near its top is crossed by a wind approximately at right angles to its axis, it often happens, particularly during winter when there are no protecting leaves on the trees (or at any time if the forest is pine), that, in the leeward valley, one hears a low sighing or moaning noise which, as the wind over the crest grows to a gale, gradually swells to a cataract roar. This, too, is only another instance of the combined effects of myriads upon myriads of æolian whispers, accentuated, indeed, along the valley through their crude focusing by the descending winds.

ODDS AND ENDS

In addition to the above, there also are numerous other sounds that might, more or less justly, be called meteorological, such as the *rustle of leaves*, due to the rubbing together of the foliage as trees and branches are shaken by the wind; the *roar and whir of the tornado*, due to the wrecking by the storm of all things in its path, to the wind eddies engendered by every obstruction, and to the more or less continuous rumble of thunder; the *patter of rain*, due to the successive falling of innumerable drops on to a roof, pavement, compact soil, and the like, or into a body of water; the *rattle of sleet* (frozen raindrops), due to the driving of the small ice pellets against any hard object—the windowpane, for instance; the *clatter of hail*, due to the fall of relatively large lumps of ice upon a roof, or other hard surface, and even (occasionally reported in connection with severe storms) to their striking together in mid-air; the *detonations of meteorites*, due to violent disruptions owing to their sudden and intense heating; the *sizzle of St. Elmo's fire*, the faint crackle of the constant stream of feeble electric discharges from mast tips or other points thus strangely illuminated; the *swish of the aurora*, due, apparently, to autosuggestion, and, of course, many more.

[1] *Ann. d. Phys.*, p. 216, 1878. See also Lord Rayleigh, *Phil. Mag.*, p. 433, 1915.

[2] *Göttingen Nachrichten*, 1912, *Heft*, p. 547.

[3] *Phys. Zeit.*, p. 49, 1912.

Science and National Progress

Edited by a Committee of the National Research Council

Dr. Vernon Kellogg, Chairman, Dr. R. M. Yerkes, H. E. Howe

WHAT DO YOU KNOW ABOUT DIATOMS?*

By H. P. Little, Secretary,
Division of Geology and Geography, National Research Council

The National Research Council is a co-operative organization of the scientific men of America. It is established under the auspices of the National Academy of Sciences and its membership is largely composed of appointed representatives of the major scientific and technical societies of the country. Its purposes are the promotion of scientific research and of the application and dissemination of scientific knowledge for the benefit of the national strength and well-being.

What is a diatom? The dictionaries and the botanists say that the Diatomaceæ are "a family of microscopic algæ inhabiting fresh and salt water. Each individual . . . consists of two more or less silicified halves, the older of which is slightly larger than the younger and fits over it like the lid of a box." Microscopic, algal, silica-covered, box-like, or even better, pill-box-like—there is the story, especially when it is added that the algæ are a very simple type of plant without roots, stalks, or seeds.

Why are diatoms interesting? Why did the National Research Council interest itself in advancing research on these minute plants and why were the Bureau of Fisheries, the Coast and Geodetic Survey, the Hydrographic Office, the Geological Survey and the National Museum so willing to give effective coöperation in this research?

The Bureau of Fisheries was interested because diatoms furnish food to fish, oysters and other fresh and salt water animals to the extent of countless millions of tons per year. Even to many of the whales they furnish an appreciable quota of their food consisting of material strained out of the sea-water by the so-called whalebone—"so-called" because it consists not of bone but of flat horny plates developed from the palate. The breeding grounds, feeding grounds, and migrations of many of our important food fishes are determined by, and vary with, the existence of adequate supplies of living diatoms of various kinds. Evidently the Bureau of Fisheries, concerned with discovering the best methods of utilizing the resources of the sea, could not fail to be interested in forwarding any kind of research which promised more intimate knowledge of forms so vitally connected with the great natural food resource. And now that the days of cheap meat are past, and fish furnish so important a quota of food, Mr. Everyman is evidently interested in diatoms, too.

The Coast and Geodetic Survey and the Hydrographic Office were concerned because navigation is helped by diatom investigations. Everyone knows that there are ocean currents of varying strength and direction and that they influence the course of ships. Navigation charts show these currents, so far as they are known, but such knowledge is by no means complete. The Prince of Monaco, who has recently been received with honors in the United States, has done much investigation of currents by releasing numerous floating bottles which contained the address to which the ultimate finder should return them. Recently, before the National Academy of Sciences in Washington, he told how successful he had been, from the knowledge thus obtained, in forecasting the course which mines released in the recent war would take, to the great benefit of shipping. Now some varieties of diatoms are restricted to specific areas as breeding grounds, and since their skeletons, because of their exceeding minuteness, sink with great slowness and are carried by currents thousands of miles from their original habitat, they serve as millions of floats to mark the course of currents, just as did the Prince's bottles. It seems very likely that a critical study of marine diatoms will reveal other species which are restricted and hence will give the hydrographer still more aid in his difficult task. A specific and interesting example of the possible use of diatoms as markers of ocean currents is found in the investigation of arctic waters which bring ice-bergs from the north into the path of ocean-going vessels and cause wrecks such as the "Titanic" disaster of 1912. Since these little plants prosper amazingly in the cold arctic waters, it is likely that they would be of assistance in tracing the origin and course of the iceberg-bearing currents. At any rate, such a possibility has commended itself to the Government Board which is studying the matter.

The Smithsonian Institution is interested in diatoms from their relation to the general progress of human knowledge and information. Their exact relations in the world of plants are not entirely clear and their classification within their family is incomplete. The fulfilment of the practical uses above referred to and others still to be given is evidently closely joined with the type of work with which the Smithsonian Institution is particularly concerned.

The Geological Survey and individual geologists have a direct interest in diatoms, and in several ways. For one thing diatoms in past geologic ages indicated, as now, climatic elements and other environmental conditions of by-gone ages, such as degree of alkalinity or acidity of waters then existing. There is also a distinctly practical side in the relation of diatoms and geology. Take the present oil boom. The California oil fields are exceeded in production, among those of the United States, only by those of the Mid-continental field; state for state, she outranks them all. Of California's production the Sunset-Midway oil field furnishes nearly half and includes the Lakeview Gusher which yielded 8,000,000 barrels of oil in eighteen months. According to a recent publication of the United States Geological Survey the petroleum in this field "has originated . . . chiefly from the alteration of organic matter contained in diatoms and formanifers. . . ." Different species of these diatoms lived at different times; oil may have formed in associated beds and by identifying the species of diatom the relative positions of the oil-bearing horizons can often be determined. Furthermore, the remains of the diatoms themselves are used in so many ways in common things that probably everyone in civilized countries buys diatoms as frequently as he buys clothes. For instance, their sharp-edged siliceous skeletons make an excellent mild abrasive which is extensively used in tooth pastes and in various kinds of scouring powders, especially for metal polishing. Various porcelains contain the remains of diatoms and special filters are made from them. According to *Mineral Resources*, published annually by the United States Geological Survey, the skeletons of diatoms find the following additional uses: as a holder of nitroglycerin in dynamite because of their porosity in the aggregate; as an insulating packing material for safes, steam boilers, and metallurgical apparatus, because of their porosity, lightness, and non-conductivity of heat; in making insulating brick and as a fire-proof building material; and in the making of records for talking machines. Germany, partic-

*Based, in large part, on the report of the National Research Council's Committee on Paleobotany, David White, Chairman.

ularly, has found various advantageous uses; the preparation of artificial fertilizers especially in the absorption of liquid manures; the manufacture of waterglass—the increasing number who "put down" their eggs to beat the high cost of living will appreciate this—of various cements, of glazing for tiles, and of artificial stone; as a carrier of ultramarine and various pigments, aniline and alizarin colors; in filling paper; and in the preparation of sealing wax, fireworks, gutta-percha objects, Swedish matches, solidified bromine, papier mâché, and many other articles. The Geological Survey is expected to keep manufacturers informed as to the location of adequate supplies of the right kind of diatom deposits for these and other industrial uses; they are of necessity interested in research which throws light on material offering possibility of such varied applications.

There is another use of diatom remains which is of particular interest, and that is in the refining and clarifying of sugar—and here again Mr. Everyman becomes mightily interested. Several years ago, the eastern refineries began to filter their juices through diatom remains, though the uninitiated would not have recognized them traveling under the name of *kieselguhr*. Recently* experiments have been carried on in Louisiana attempting to devise methods of utilizing the Louisiana sugar houses for refining raw sugar from abroad in their inter-season periods of idleness without the use of bone-black. In these experiments the "melted sugars are best first clarified with *kieselguhr* . . . "

The diatom is a plant of marked esthetic qualities as well as of much practical value and scientific interest, though unfortunately these cannot be appreciated without the aid of a microscope. The writer for many years exhibited each year a microscope slide less than a quarter of an inch square; this small square was divided into one hundred smaller squares and in each of these reposed the skeleton of a diatom and under each was written its long technical name; often as many as twenty letters. Yet the admiration of the students was always divided between the minute technique of the maker of the slide and the beauty and variety of the forms exhibited. There are over 10,000 known varieties of these artistic forms. Often the siliceous cover is ornamented with very fine lines, sometimes 125,000 to the inch, so that in the past they were used to test the fineness of high power microscope lenses.

The remains of diatoms are known most abundantly as beds of rocks composed largely of their remains and go under the name of diatomaceous earth, infusorial earth, and *kieselguhr*. They are accumulating today on the bed of the oceans, and in many lakes, as in some of the lakes of Maine where their remains when dredged out dry into a beautiful pure white, flour-like substance of great purity. But such details have no place here. Neither have questions of the money value of the product, though it is perhaps necessary for the sake of leaving a correct impression to say that the value of the raw material produced in the United States is not great at the present time. Fortunately, this country has large resources of material which can be drawn upon as necessity demands.

This, then, is the case for the diatom; these the grounds on which are asserted your interest in a plant you did not know. The evidence would seem to be valid, for when the National Research Council found that diatom research was not adequately supported in this country—in fact was practically unsupported—and attempted to obtain funds to endow such research, the funds were forthcoming and are now being most advantageously utilized.

A NATIONAL INFORMATION SERVICE FOR SCIENCE AND TECHNOLOGY

By Ruth Cobb, Research Information Service,
National Research Council

THE Research Information Service of the National Research Council, a busy exchange for scientific knowledge, begins its third year with increased financial resources and with the determination to double its scope and output. Already it has relieved some investigators of the drudgery of routine compilation and irksome thumbing through a mass of literature by telling them what they want to know when they want to know it. It has also relieved them of the annoyance of answering repeated questions about themselves and their work by collecting the facts once and for all to pass on to those who ask. By protecting the specialist from interruptions to his constructive research it is saving the razor edge for finer work than cutting wood.

One way in which the Information Service is increasing its value to the research worker is by the preparation of lists of published and unpublished bibliographies. This "bibliography of bibliographies" on subjects connected with all of the natural and applied sciences lists manuscripts, card indexes, periodical catalogues and abstracts, books and authors' appendices to monographs. If scientists will appeal to the Service for the bibliographies they need before compiling their own, reference lists now in existence will be more often consulted and much unnecessary work will be saved.

The Service is also constantly making surveys for the collection of such information as will be of use in answering the inquiries that are put to it in steadily increasing number. Whenever the information so collected is of sufficient interest and importance to justify wide distribution, it appears as a circular or bulletin of the Council. As the natural sequence of such surveys there has been published a list of the doctorates conferred in 1920 by American universities and a list of periodic technological and scientific bibliographies, abstract journals, and systematic handbooks that are issued at home and abroad. Usually the information in these bulletins becomes the beginning of a permanent file which is corrected and enlarged at every opportunity. When there is sufficient demand the original bulletin is brought up to date and a new edition appears. There is now in preparation a second edition of *Bulletin of the National Research Council*, No. 2, which will give the name of the director of research and some information about the staff, research work, and equipment of about 500 laboratories in industrial establishments of the country. Similar records for several hundred academic and private laboratories are also on file.

The Service has other informational files of records which it is not feasible to publish. Accounts of some 12,000 of America's leading scientists and a special war-time group of chemists and mining engineers listed by the Bureau of Mines may be consulted through the Service. These records are being brought up to date, supplemented, and so classified that individuals meeting any reasonable specifications may be easily selected. Facts about investigations in progress are continually noted, but because of the difficulties met with in actively seeking data of this kind and keeping them current, the file is far from complete. It is being gradually perfected, however, as the other activities of the Service develop.

A bulletin on funds available in 1920 in the United States for the encouragement of scientific research has just been issued by the Council. It gives an account of medals, prizes, grants and research scholarships and fellowships amounting in value to something like thirty-six million dollars annually. With this as a nucleus, an up-to-date file of information on research funds is being developed. The Service is also listing the principal working sources which it discovers for each type of scientific information. In this source file are included other informational bureaus, individuals, selected industrial, academic and federal laboratories, special libraries, and independent research institutions. It is used by members of the staff as a starting place in answering questions on a great variety of scientific subjects.

Through the "miscellaneous request service," information about all kinds of scientific and technological activity is sent to those who seek it. Questions are answered concerning research problems, projects, work in progress and results; methods and processes; laboratories, equipment and apparatus;

*See *Journal of Industrial and Engineering Chemistry*, Feb., 1921, p. 150.

publications, funds and personnel. There is no charge for replies which do not require a special search; charge for information which calls for elaborate compilation or search through a vast amount of material merely covers the cost of labor.

To carry on this work the Research Information Service has a resident technical staff consisting of its director, Dr. Robert M. Yerkes, six scientific associates and two technical assistants. Each associate is responsible for answering questions which lie within the field of his special interest: physical sciences and engineering, chemistry, geology and geography, biology and agriculture, medical sciences, and anthropology and psychology. Each has also under his direction one or more of the special projects for the whole field of science, such as collecting information about scientific personnel or funds for the aid of research. The technical staff, when necessary, calls upon other resident members of the Council for advice or assistance, or consults with specialists in the federal scientific bureaus.

The Service has among its advisory members, in addition to the chairmen of the various divisions of the Council and a representative from each department of the Federal Government, twenty specialists in widely divergent fields. These members at large include representatives of important industries, leading scientific and technical libraries and educational institutions in all parts of the country.

Through its membership contacts with academic, industrial and federal activities at home and abroad, the Service has access in an unusual degree to the most reliable sources of up-to-date scientific information. As a division of the National Research Council it enjoys the privilege of coöperative relations with the national scientific organizations of other countries. It regularly exchanges informational publications with the British Department of Scientific and Industrial Research and the Advisory Council for Scientific and Industrial Research of Canada, and exchanges information as occasion arises with the corresponding organizations of France, Italy, Japan, Australia, New Zealand and South Africa. This widens the scope of its usefulness to the scientists of America by providing a channel through which they may learn of the plans and accomplishments of science abroad.

The Service wishes and expects to coöperate with many other informational sources now operating in the country, for it believes in utilizing rather than duplicating labor. In cooperation with *Special Libraries* it has just assisted Mr. W. I. Swanton, of the Reclamation Service, in preparing for publication a reference list of 170 Washington libraries. This list gives the location of the library, the name of the librarian, a general account of the subjects covered by each collection of books and the approximate number of volumes. The establishment of a reprint and informational exchange service with the James J. Hill Reference Library of St. Paul, Minnesota, is now being planned. The interests and aims of the two organizations have so much in common that each should be of great help to the other in locating scientific materials and making them accessible through the proper distribution of surplus numbers and the photostating of rare publications.

The Research Information Service does not itself carry on any research work, but it is in close contact with its sources and keeps itself informed about laboratories, institutions and men who are advancing the scientific knowledge of the world.

Research Work of the United States Bureau of Standards

Notes Specially Prepared for the SCIENTIFIC AMERICAN MONTHLY

SIMPLE RADIO RECEIVING SETS

THE radio laboratory of the Bureau of Standards is cooperating with the Bureau of Markets of the Department of Agriculture in the establishment of a system of broadcasting market reports by radio. Since this system has been started, a great many people previously not concerned with radio work have become interested in this subject, and it therefore, seems important to secure all possible information regarding available radio apparatus which is suitable for receiving these reports.

The Bureau of Standards is enlisting the co-operation of manufacturers by asking them to write to it with a view to submitting for test such sets as they manufacture or may develop for the purpose mentioned above. It is likely that a considerable demand for this equipment will develop among farmers, shippers, chambers of commerce, radio clubs, and others who are interested in receiving directly radio market reports. As a result of the investigation now begun by the Bureau, it is hoped that specifications may be prepared covering the requirements as to behavior and usefulness which such sets should meet.

CONFERENCE ON AERONAUTICAL SAFETY CODE

ON May 13, a conference was held in Washington to consider the development of an Aeronautical Safety Code for which the Bureau of Standards and the Society of Automotive Engineers have been designated as the joint sponsors by the American Engineering Standards Committee. This conference was attended by representatives of the War, Navy, and Post Office Departments, the National Advisory Committee for Aeronautics, the National Safety Council, Manufacturers' Aircraft Association, and the Insurance Underwriters, as well as representatives of the two sponsors and the American Engineering Standards Committee.

It was the sense of this conference that a safety code ought to be developed without delay and that a committee should be formed at once which would include representatives of all organizations interested in this subject as well as those which were present at the conference. Invitations have, consequently, been extended to other interested organizations.

FOURTEENTH ANNUAL CONFERENCE ON WEIGHTS AND MEASURES

THE Fourteenth Annual Conference on Weights and Measures was held at the Bureau of Standards on May 23-26. Invitations had previously been sent to the governors of states, mayors of various cities, and weights and measures officials throughout the country. The governors of those states which do not maintain an office of weights and measures were in every case urged to appoint delegates to the conference and many took advantage of this opportunity to send a representative to the Bureau. Manufacturers of apparatus and persons engaged in weights and measures work for industrial concerns, associations, etc., were also present. Several of the manufacturers had on exhibition various weights and measures appliances, including scales of all sorts, machines for automatically measuring the yardage of cloth, liquid measuring pumps, etc.

The main object of these conferences is to secure uniformity in weights and measures standards and laws and in the enforcement of the latter. Only fundamental questions of weights and measures are considered; the aim of the conference being rather to direct the general subject than to go too much into detail. Among the speakers were Mr. Herbert

Hoover, Secretary of Commerce; Dr. S. W. Stratton, Director of the Bureau of Standards, and numerous officials of State Weights and Measures Departments. The subjects treated included the sale of bread by weight, the detection of shortages, the weighing of coal, and tests of liquid measuring pumps.

STANDARD TESTS FOR AUTOMOBILE BRAKE LININGS

AT a conference recently concluded at the Bureau of Standards, recommendations were made for a standard method of testing brake lining materials for automotive purposes; the engineers of the Bureau discussed these recommendations with representatives of nearly all the manufacturers of this class of material, as well as of the Motor Transport Corps of the Army and the Standards Committee of the Society of Automotive Engineers.

In view of the very large quantities of brake lining material used in automotive vehicles to-day, the establishment of standard test conditions which may be used by all makers and large users and which can form the basis for purchase specifications is of considerable importance, not only to the industry but also to the public. Such standards carefully planned tend to bring about a greater uniformity of the materials concerned, and by establishing a better understanding of the essentials leave the manufacturer free from unnecessary restraint in other directions, so that he may use all his energy and ingenuity toward the improvement of the materials and his methods of production.

At the suggestion of the Motor Transport Corps, the Bureau of Standards, about a year ago, undertook an investigation to determine the most suitable conditions for such standard tests, and this conference was called to explain to those most interested the results of this work and to discuss proposals based on these results.

Dr. S. W. Stratton, Director of the Bureau, opened the meeting with a short address in which he dealt with the work of the Bureau in general and referred to the numerous occasions on which the Bureau has been able to assist the industries, by investigating problems of this nature, and by cooperating in the establishment of standards and the preparation of specifications.

Dr. H. C. Dickinson, Chief of the Automotive Power Plants Section, followed with some remarks covering the brake lining investigation in particular and the results that were expected from it.

A full report and analysis of the work was then presented by the engineer in charge of the investigation, who concluded by submitting the Bureau's recommendations for the test as based on the results obtained.

A thorough discussion, during which the experience of many of those present was freely offered, followed and led to a very satisfactory agreement.

The interest of the brake-lining industry in this work was well shown by the large attendance and the thoroughness of the discussion. Many of those present expressed their appreciation of the assistance rendered by the Bureau and the hope that the Bureau, whose activities in the automotive field are only a recent development, would be able to co-operate with this industry to an increasing extent in the investigation of many important problems calling for consideration.

PAPER AND COTTON COMPARED TO BURLAP FOR SANDBAGS

THE results of a study which the Bureau has been conducting of paper and cotton bags for use as sandbag fortifications has been published in the Paper Trade Journal for May 19, 1921, under the title "Suitability of Paper and Cotton Bags in Relation to Burlap Bags for Sandbags." This work was undertaken for the War Department and the purpose of the investigation was to determine whether or not these materials could be used satisfactorily in sandbag fortifications or trenches.

The work included a large amount of laboratory testing and also experiments in service to find the value of this material when made up into bags. All tests in this investigation, with the exception of those on wet material, give results which indicate that a rope paper would be a very good substitute for burlap. This paper, however, is very weak when it becomes wet. If it could be waterproofed, this difficulty would be eliminated. However, at the present time the waterproofing of paper is only in the experimental stage. Many formulæ for waterproofing have been patented but when they are tried out in the paper mills it is found that they either do not waterproof at all or destroy the suitability of the paper for the purpose for which it is to be used. Practically all the work on waterproofing to-day has dealt only with the chemical treatment of the fiber, either before or after the paper has been made, while very little has been done on the scientific control of beating processes in the manufacture of paper.

The Bureau plans to investigate this problem thoroughly and by the use of chemicals combined with scientific control of the beating to manufacture, if possible, a paper similar to that mentioned above and yet waterproofed sufficiently to make it suitable in every respect for sandbags.

Since the paper just mentioned contains 30 per cent manila and jute rope stock which might be hard to obtain in time of war, it is probable that the Bureau will also undertake to manufacture a 100 per cent sulphate fiber paper that will be as strong as the above rope paper.

TESTS OF BRAZED COPPER SHEETS INTENDED FOR ROOFING PURPOSES

RECENTLY the Library of Congress submitted for test some copper sheets for roofing purposes which had been joined by brazing. Two types of joints were used, a simple "lap" joint and a "lock" joint in which the edges of the two sheets to be joined were first bent double and then "locked" into one another.

The series of examinations indicated that of the two types of joints, designated as lap and lock, the lap joint is superior in strength and much more desirable in its structure. In forming the lock joint, apparently it is necessary to apply the heating torch for a considerably longer period in order to cause the metal to flow into the joint. In doing this, the upper fold of the sheet which forms the lock is highly heated and often burnt. It was noticed in most cases that none of the brazing metal penetrated directly below the upper fold so that the upper sheet could easily be bent along the line of the junction. It appears from the results of this examination, that if the buckling of the sheets which apparently cannot be entirely prevented with this method of joining sheets, is not too objectionable, the lap joint should be satisfactory for the purpose. The lock joint is decidedly inferior in strength and other properties to the lap joint.

It may be pointed out that the joints should be *carefully* cleaned after brazing. In the specimens submitted the film of zinc chloride remaining after cleaning the specimens was sufficient to accelerate atmospheric corrosion very decidedly within a very short time.

METHOD FOR DIFFERENTIATING AND ESTIMATING UNBLEACHED SULPHIDE AND SULPHATE PULPS IN PAPER

TECHNOLOGIC PAPER 189 bearing this title has just been issued and may be obtained from the Superintendent of Documents at 5 cents per copy. The purpose of this paper is to fill a need felt especially by paper chemists and analysts for a rapid and reliable method of distinguishing between and of making an approximately correct determination of mixtures of unbleached sulphide and sulphate pulps.

This paper gives briefly the basic differences in the manufacture of the two pulps and contains a concise review of the methods that have been recommended from time to time for distinguishing between them. It gives the procedure followed

In developing a new and comparatively rapid method for distinguishing between these pulps and also gives some of the more important experiments carried out with various stains during this investigation. The method of preparing the new stain and the method of procedure for differentiating between unbleached sulphide and sulphate fibers is described in detail and tables showing the results of quantitative microscopical analysis of mixtures of these fibers stained by the new method are given.

RULING SCALE BY LIGHT WAVES

IT is interesting to note that it is now possible to construct scales for the measurement of length directly from the fundamental wave lengths of light without the use of any intermediary standard. As an example of work of this sort which is now being regularly carried out, it may be mentioned that the Bureau recently completed the rulings on a six-inch scale using light waves from a tube containing Neon (wave length 5800 to 6600-A) as the length standard. The work was done for and the scale has been delivered to the Brown & Sharp Manufacturing Company.

RESEARCH WORK ON ELECTRODEPOSITION

DURING the past month a member of the Bureau's staff attended meetings of the American Electrochemical Society in the interests of research work on electrodeposition. A great deal of interest was shown in the proposed program and plans were made for the formation of a division of the Society to be concerned wholly with this kind of work. If such a division is organized, it will be a distinct advantage in bringing together persons interested in this field and in so doing it will stimulate research work along electrochemical lines.

Letters have been sent out by the National Research Council to about 200 representative manufacturers in whose plants electroplating is an essential process. The purpose of these letters is to inquire whether they would be willing to furnish financial support toward research work on electrodeposition. If such support is received, it is expected that the funds will be expended for research work conducted at the Bureau of Standards under the general supervision of a representative advisory board.

PYROMETRIC PRACTICE

TECHNOLOGIC PAPER No. 170, "Pyrometric Practice," is now available. This publication has already been adopted in several universities as a standard text for teaching pyrometry. Copies may be purchased from the Superintendent of Documents, Government Printing Office, Washington, D. C., at 60 cents per copy.

Research Work of the U. S. Forest Products Laboratory

Notes Specially Prepared for the SCIENTIFIC AMERICAN MONTHLY

BAKING POWDER AND ARTIFICIAL LEMONADE FROM WESTERN LARCH

IN an analysis of western larch the Forest Products Laboratory has found that the wood contains a large quantity of a water-soluble gum called galactan. This gum can readily be turned into mucic acid, which can be used as a substitute for tartaric acid in baking powder and citric acid in artificial fruit flavors. This discovery will soon be put into commercial application by the erection of a plant in Montana for the extraction of galactan from larch. The gum thus obtained will be used in the production of baking powder and in the manufacture of soft drinks.

PLAN CAMPAIGN FOR THE PROTECTION OF MINE TIMBERS

HOW TO get the mining industries interested in protecting more of the wood used in mines against decay is a problem upon which both the Forest Products Laboratory and the Bureau of Mines are now working in coöperation. The problem is not one of testing out preservatives so much as conducting a publicity campaign which will bring to the attention of the mining companies the facts about the tests that have already been made.

At least three preservatives have been found suitable for mine work. These are coal-tar creosote, zinc chloride and sodium fluoride. Creosote is the most effective in preventing decay. Timbers thoroughly impregnated with it are likely to resist decay until they are crushed or worn out. Occasional objection is made to the possible fire hazard of creosoted wood, but long experience indicates that the additional fire risk is very small. Zinc chloride and sodium fluoride are odorless, and if anything they tend to reduce the inflammability of wood. They are cheaper than creosote, and although they do not give such permanent protection they greatly increase the life of timbers. Coal-tar creosote may be applied by the brush, dipping, open-tank, or pressure methods. Zinc chloride and sodium fluoride may be injected by the steeping, open-tank, or pressure methods. The cost and effectiveness of the methods of treatment increase in the order given. The saving possible with any of them is so great that it will pay every mine to adopt the use of some preservative on permanently located timbers.

DIRECTION OF GRAIN AFFECTS STRENGTH OF PAPER BOXES

PAPER has grain the same as wood has, and the Forest Products Laboratory has found that the strength of a box made of paper or fiber board is affected by the direction in which the grain runs in the sides, top, and bottom. Fiber boxes are scored at the corners to make them fold without breaking. If the fibers in the paper run so that they lap around the corners, the box is stronger than if the fibers run parallel to the folds. No attention has been paid to this fact heretofore in the manufacture of paper boxes.

WHEN IS THE BEST TIME TO CUT TIMBER?

MANY of the theories which have been advanced regarding the durability of wood attribute too much importance to the time of cutting. As a matter of fact, the time of cutting has very little effect upon the durability or other properties if the timber is properly cared for after it is cut. The method of handling logs at different times of the year, however, does influence their durability.

Timber cut in late fall and winter seasons more slowly and with less checking than during the warmer months, and when proper storage or handling is impracticable, winter cutting is best. Fungi and insects do not attack wood out of doors in cold weather, and by the time warm weather arrives the wood is partly seasoned and somewhat less susceptible to attack. It is for these reasons that winter cutting is advantageous, and not on account of a smaller amount of moisture or sap in the wood in winter, as the popular belief has it. There is practically no difference in moisture content of green wood in winter and summer.

Notes on Science in America

Abstracts of Current Literature

Prepared by Edward G. Spaulding, Ph.D., L.L.D., Professor of Philosophy, Princeton University

THE INFLUENCE OF ENVIRONMENT ON SEXUAL EXPRESSION IN HEMP

In the *Botanical Gazette* for March, 1921, Professor John H. Schaffner of Ohio State University presents the results of a series of interesting experiments, covering a period of some years, on the influence of environment on sexual expression in hemp.

The study of hemp, *Cannabis Sativa L.*, was originally undertaken to determine what influence the environment might have on the sex ratio between staminate and carpellate plants.

It soon became evident, says the author, that far more fundamental problems were presented for solution than the mere changing of sex ratios. Intermediate plants appeared, bearing both stamens and carpels. There was also an endless profusion of abnormal flowers involving all sorts of sexual expressions; and, most remarkable of all, complete reversal of sexual expression under the influence of an abnormal environment presented itself as the most interesting phenomenon to be studied.

Professor Schaffner then gives a detailed account of his experiments, the conclusions from which may be summarized as follows:

1. Hemp planted in spring in the open, under normal conditions, developed as pure carpellate and pure staminate individuals. There was no confusion of sexuality.

2. The ratio between carpellate and staminate individuals is about 1:1, with a large deviation in either direction for various plots.

3. Hemp planted in winter in the greenhouse on shallow benches with low light intensity showed great confusion in sexual expression. Abundant irregularities were produced, such as stamens with normal stigmas and structures partly carpellate and partly staminate, as well as more typically bisporangiate flowers and flowers typical of the opposite sexual state.

4. Both carpellate and staminate plants showed reversal in their growing period to the opposite sexual state.

5. In extreme cases 88 per cent of carpellate plants showed reversal to maleness, and 80 per cent of staminate plants showed reversal to femaleness.

6. Both staminate and carpellate plants, although they showed decided sexual dimorphism, contained all the factors and abilities of both sexes. There is no question of a homozygous or heterozygous condition involved. The staminate and carpellate individuals contain the potentialities for the perfect development of the opposite sex. Reversal of the sexual state takes place in the vegetative tissues, and has no relation to a reduction or segregation of chromosomes or their possible hereditary factors.

7. The sexual reversal is of all degrees of intensity, from very imperfect expressions of the opposite organs to completely normal development.

8. Sexuality is a state or condition not Mendelian in nature, but related to the functional activity of the plant and profoundly influenced by environment. Maleness and femaleness in hemp are probably controlled by the metabolic level of the cells, and sex reversal takes place when the metabolic level is decidedly changed or disturbed.

9. Any tissue in its growth may be in a neutral state of varying degrees of intensity; and during its continued growth can pass from one state to the other without any reference to chromosome segregation or combination which are the ordinary causes of Mendelian phenomena.

10. Sex is subject to experimental control in the individual in such dimorphic, diœcious species as hemp, and such control can be exercised in various ways by changing the ordinary factors of environment, and, therefore, presumably also by chemical and physical stimuli of various kinds.

WATER AND SEEDS

In the *Journal of Agricultural Research* for January, 1921, Mrs. George J. Bouyoucos and M. M. McCool of the Michigan Agricultural Experiment Station, present an interesting article on the measurement of the amount of water that seeds cause to become unfree and their water-soluble material.

In introducing their article, the authors say:

It has been shown that soils cause water to become inactive or unfree, as is indicated by its refusal to freeze or to function as a solvent. The magnitude of this unfree water has been measured by means of the dilatometer method, which has proved most convenient, appropriate, and unique for this purpose. The principle of this method is based upon the fact that water expands upon freezing. If the amount of expansion that a certain amount of water (1 gr.) produces upon freezing is known, then the quantity of water that freezes in the soil can be calculated from the magnitude of expansion produced.

It is, of course, very well known that seeds absorb large quantities of water and with a considerable force. Seeds like the lima bean, cowpea, soybean, clover, and alfalfa absorb over 100 per cent of their dry weight of water. The great attraction that seeds have for water is best realized by the fact that they will abstract the moisture from the soils even down to the point of air-dryness. Whitney and Cameron found, for instance, that when 50 gm. of seeds of cowpeas were mixed with 50 gm. of soil containing 15 per cent of water, the seeds had in 12 hours gained 12.1 per cent of water and had left in the soil only 1.3 per cent, that is, the soil was reduced practically to air-dry condition. It appears, therefore, that the power of seeds to absorb water is greater than that of soils.

Since it was found that soils cause water to become unfree, the extent varying with the character of the soil, the question arose whether the seeds also cause water to become unfree, and if so, to what extent.

In order to obtain information bearing upon these questions a general investigation of the problem was undertaken by the authors. The type of dilatometer used and the general procedure followed were the same as those used in the study of soils. The procedure consisted in weighing out carefully about 10 gm. of air-dry seeds and placing them in water to soak for about two days. Then they were taken out, pressed between filter papers in order to eliminate their excess of water, weighed again quickly, and introduced into the dilatometer. The unoccupied space in the dilatometer was then filled with ligroin, and care was taken to expel all the air. The mouth of the dilatometer was then carefully stoppered, and the contents were placed to cool in a temperature of 3° C. When this temperature was attained by the contents, as indicated by the column of ligroin in the stem, which remained stationary, the water in the seeds was caused to freeze. This was accomplished by taking hold of the dilatometer by the stem and moving it gently in the cooling mixture until solidification began, which was indicated by the rise of the ligroin in the stem. The dilatometer was allowed to remain in the cooling mixture with frequent movements until the rise of ligroin in the stem ceased. The total rise of the ligroin in the stem was taken to represent the total amount of expansion due to the formation of ice.

The results of their investigation are then presented in detail and analyzed. They may be summarized as follows: The amount of water that seeds cause to become unfree is very large, varying from 25.05 per cent in broom corn to 76.76 per cent in black soybeans, based on the air-dry weight of seeds. Repeated freezing and thawing tends to diminish considerably the amount of unfree water, especially in some seeds.

Dry seeds contain a large amount of water-soluble material, as is evidenced by the high freezing-point depression. When 10-gm. portions of seed flour are mixed with 20 cc. of water and the mixture is allowed to stand for about 40 minutes or less, the freezing-point depression varies from 0.280° C. in wheat to 1.180° C. in speckled wax beans. At very low moisture content the magnitude of this depression must be very great. The magnitude of the osmotic pressure must also be correspondingly very great.

The great power that seeds possess to absorb water and to abstract it from the soil is partly if not largely due to their tremendous internal osmotic pressure.

THE NATURE OF LIFE AND DEATH

SCIENCE for April 15, 1921, contains an interesting article by Professor W. J. V. Osterhout on the nature of life and death.

Some of the fundamental ideas of biology are extraordinarily difficult to analyze or define in any precise fashion. This is true of such conceptions as life, vitality, injury, recovery and death. To place these conceptions upon a more definite basis it is necessary to investigate them by quantitative methods. To illustrate this Professor Osterhout considers some experiments made upon *Laminaria*, one of the common kelps of the Atlantic coast.

The author finds that the electrical resistance of this plant is an excellent index of what may be called its normal condition of vitality. Agents which are known to be injurious to the plant change its electrical resistance at once. If, for example, it is taken from the sea water and placed in a solution of pure sodium chloride the electrical resistance falls steadily until the death point is reached; after which there is no further change. Study of the time curve of this process shows that it corresponds to a monomolecular reaction (slightly inhibited at the start).

This and other facts lead to the assumption that the resistance is proportional to a substance, M, formed and decomposed by a series of consecutive reactions. On the basis of this assumption one can write an equation which allows us to predict the curve of the death process under various conditions. This involves the ability to state when the process will reach a definite stage, *i.e.*, when it will be one-fourth or one-half completed. This can be determined with considerable accuracy.

This curve is of practical, as well as of theoretical, importance, since it allows one to compare the degree of toxicity of injurious substances with a precision not otherwise attainable. The best way of doing this is to proceed as a chemist might in such cases and express the degree of toxicity by the velocity constants of the reaction (*i.e.*, of the death process) under various conditions.

From this point of view the death process must be regarded as one which is always going on, even in an actively growing normal cell. In other words the death process is a normal part of the life process. It is only when it is unduly accelerated by a toxic substance (or other injurious agent) that the normal balance is disturbed and injury or death ensues.

Putting this into chemical terms, we may say that the normal life process consists of a series of reactions in which a substance O is broken down into S, this in turn breaks down into A, M, B, and so on. Under normal conditions M is formed as rapidly as it is decomposed and this results in a constant condition of the electrical resistance and other properties of the cell. When, however, conditions are changed so that M is decomposed more rapidly than it is formed, the electrical resistance decreases and it is found that other important properties of the cell are simultaneously altered.

Hence it is evident that injury and death may result from a disturbance in the relative rates of the reactions which continually go on in the living cells.

The author then gives the details of his experiments, and concludes:

It is evident that if the facts have been correctly stated such fundamental conceptions as vitality, injury, recovery and death may be investigated by quantitative methods. This leads us to a quantitative theory of these phenomena and a set of equations by which they can be predicted. It may be added that the predictive value of these equations is quite independent of the assumptions upon which they were originally based.

This investigation of fundamental life processes shows that they appear to obey the laws of chemical dynamics. It illustrates a method of attack which may throw some light upon the underlying mechanism of these processes and assist materially in the analysis and control of life-phenomena.

THE DEPENDENCE OF THE FISHES ON THE DIATOMS

IN *Ecology* for April, 1921, Dr. Albert Mann of the Carnegie Institution discusses the Dependence of the Fishes on the Diatoms. In introducing his discussion Dr. Mann says that to make clear the extent of the service the diatoms render in this respect and the opportunity they offer for improvement in fish-culture methods, it is necessary to state a fact, evident enough but easily overlooked, namely, that in the sea as on the land the fundamental supply of all food comes from vegetation; that the elements necessary for life are as hopelessly beyond the reach of aquatic animals as of terrestrial animals; and that fecundity and growth are as rigidly proportionate to the abundance of plant-life in the sea as on the land. In consequence of this, the ocean has its fertile fields and its deserts as unmistakably as does the shore; and when marine plant-life is multiplied, the long chain of animal organisms directly or indirectly feeding upon it shows the same proportionate increase that is seen when all these interrelations are terrestrial.

Continuing, the author says: The diatoms are the great fundamental food supply of the aquatic world. They are the grass of the sea. They people all waters in all latitudes. They surpass in bulk, or annual productiveness, all the other aquatic plants a thousand fold. They are available as food, not only in the shallower waters along the coast, but constitute almost the only prolific form of plant-life in the open ocean. They are so minute as to be available for food for the smallest animal organisms, and yet, because of their abundance, they represent the sole food-supply of some of the larger forms. They are highly nutritious, and not one among the thousands of living species, so far as is known, is deleterious.

The diatoms differ in genera and species in different localities as strongly as do terrestrial plants. Not only are there clearly marked arctic, temperate, and torrid zone diatoms, but the contrast between the local diatom flora of one part of the country and that of another is often very marked. So general is this diversity of each locality, that it is safe to say the diatomist could recognize by a sample its geographic origin as accurately as the botanist recognizes the source of a collection of phanerograms, were our knowledge of the diatoms in different waters as full and accurate as our knowledge of terrestrial plants in different lands. And this fact being established, it is natural to carry the comparison a little further and to wonder if there cannot be some sort of *marine agriculture*, some science dealing with the improvement and multiplication of desirable sea-plants, as we deal with desirable land-plants.

The life-habits of different genera of diatoms fit them for very dissimilar habitats. Some live wholly in fresh-water, others are marine, a few invariably brackish. Many species

are attached and therefore confined to those places where submerged objects afford the necessary foothold. Others live principally or wholly on the bottom and have the power of locomotion. A very large number are pelagic, and either represent the main ingredient of the great plankton life of the ocean or constitute the food of those minute animal organisms, like the copepods, which characterize such planktons. It is evident, therefore, that the kinds of diatoms to be found in any locality, or capable of being introduced there, depend on the particular life-habits belonging to the different species.

Each species also has its seasonal period of growth. This is generally in spring or early summer, but in a few instances the maximum is in autumn. There are a few species that show a biannual increase, the second one being the smaller. In consequence of these differences, the period of the year at which a given species is at its maximum of abundance becomes an important factor in its value as a direct or indirect food-supply for migrating fishes. If it is coincident with the annual arrival of these fishes, or so precedes it as to give rise to a more prolific animal food at the time of arrival, the result will be wholly different from what would follow with diatom species developing earlier or later. There is also great variation in the abundance of certain species in successive years. The controlling factors of this erratic annual variation are at present too obscure to admit of a statement. Undoubtedly along the coast or on the open sea the major factor may be taken to be the annual changes in the great ocean currents and in those surface movements caused by wind and tide. But that these do not suffice for an explanation is proven by the fact that in quiet waters, like inland ponds and streams, the difference in the diatom flora from year to year is sometimes very great.

As the chain of interrelation between the fishes, lobsters, clams, oysters, and other edible sea forms, on the one hand, and the diatoms, on the other, is sometimes one of a single link but more often of many links, it is perhaps worth stating that the dependence of the fishes, etc., on the diatoms is as real in the one case as in the other. Some of our economically important fishes, as the menhaden, are preëminently diatom feeders; but in the very great majority of cases this is not true. A relatively large number include diatoms in their menu during the first periods of life, but soon change to a mixed or wholly carnivorous diet; and there are doubtless a good many that never feed upon them at all. But whatever the food of any species, that food in its turn must be adequately abundant, and can be so only by an ample supply of its particular food. The strength of our chain, regardless of the number of its links, is, then, dependent on that first and fundamental link which joins it organically to the inorganic elements of which all living forms are composed, elements which are unavailable until woven into living tissue on the mysterious loom of the chlorophyll-bearing plant. And this, in the entire aquatic world, is par excellence the diatoms.

Progress in the Field of Applied Chemistry

Notes Culled from Current Technical Literature

By H. E. Howe, Member of American Chemical Society

POTASH SITUATION IN GREAT BRITAIN

IN the issue of May 12 *Nature* discusses the potash situation in Great Britain and recounts briefly the well-known facts with respect to pre-war potash supplies. In 1913 the consumption of potash fertilizers expressed in tons of potassium oxide (K_2O) shows Great Britain to be the last in the list of named countries in which Germany comes first, followed by the United States, Holland, France, Austria-Hungary, Russia and then Great Britain. The United States used more than five times the potash of any other country save Germany and it is pointed out that many soils actually require less potash than German soils and elsewhere crops, such as potato, which require large quantities of potash, are not grown on so large a scale.

After discussing the efforts to reduce the production of the Alsatian deposits, due to the fact that more German capital was invested in German deposits, and the superiority of these Alsatian deposits, the discussion takes up the possibility of securing adequate supplies for Great Britain.

"In this country the only practically available source of supply is the flue-dust from blast-furnaces. It has long been known that this dust contains potash, but the amount was small, and, worse still, very variable, depending largely upon the working of the blast-furnace. As the result of a number of experiments initiated by Mr. K. M. Chance of the British Potash Company, Ltd., it was discovered that by adding a small proportion of salt to the blast-furnace charge, practically all the potash present could be volatilized as chloride and recovered in the flue-dust. Messrs. Rossiter and Dingley investigated for the above company the percentages of potash in a large number of iron-ores, and published their results in November, 1919, in the Journal of the Society of Chemical Industry. The ores richest in potash are the bedded iron stones of Secondary age, such as those of Northamptonshire, Cleveland, Lincolnshire and Oxfordshire, which showed respectively 0.42 per cent, 0.36 per cent, and 0.30 per cent of potash. When salt is added to the charge of a blast-furnace smelting these ores, flue-dusts are obtained that contain about 30 or 35 per cent of K_2O as chloride or other water-soluble salts. Such dust is, therefore, considerably richer in potash than the ordinary manurial salts hitherto supplied from Germany, and it seems probable that it could be applied direct to the land with very beneficial results, though not much work has as yet been done in this direction.

"The experiment of adding salt to the blast-furnace charge has as yet been tried in only a few works, and the bulk of the dust thus produced appears to have been worked up for potash salts at the works of the British Potash Company, Ltd., at Oldbury. In the paper already referred to, it is calculated that if the salt process were adopted in every blast-furnace in Britain, potash equivalent to 50,000,000 tons of K_2O could be recovered annually. This figure is about double that of the British consumption of potash for agricultural purposes before the war, but falls far short of the amount that we really require in this country, while it need scarcely be said that nothing even remotely approaching it has as yet been produced nor does there appear to be the slightest prospect of reaching it for many years to come.

"In the meantime, British agriculture needs potash and needs it most urgently. Agriculture is the most vital of our industries, and when the process of destroying our coal-mining industry, and with it our manufacturing industries generally, now apparently in full swing, has been consummated, it will be the only means by which the inhabitants of these islands can continue to exist. It would appear, therefore, that the best policy in our national interests is to help our French Allies to develop as speedily as possible the potash resources of their recovered province, and to obtain from them the supplies of potash which our lands, neglected in this respect during the war, so sorely need. Of course, the potash-bearing blast-furnace flue-dust would continue to be worked up, as it is at present, for the manufacture of high-grade salts of potash, and

no doubt it would be able to supply a certain proportion of the British consumption of such salts, and to this extent decrease our imports."

CARBON MONOXIDE

EACH year a large number of deaths are caused by asphyxiation, in practically all cases of which carbon monoxide is the direct cause. The gas is colorless and odorless, gives no warning and usually small animals are used as one of the reliable methods for its detection, in quantities sufficiently large to be harmful. The Bureau of Mines has been interested in the perfection of more exact detectors and Mr. C. R. Hoover recently described a new apparatus which appears to be particularly efficient. It consists of a rubber aspirator bulb attached to a six-inch tube so that a sample of air to be tested can be drawn through the tube which contains activated charcoal to remove gases which might interfere with the delicate test for carbon monoxide. The air is forced out through a glass tube containing a mixture of fuming sulphuric acid and iodine pentoxide. In the presence of carbon monoxide this white solid turns varying shades of green which increase the depth of color as the amount of the gas increases. This color is compared with a permanent scale attached to the apparatus so that the quantity of carbon monoxide is readily determined. The test requires but a few seconds and shortly afterward the color disappears from the pentoxide mixture and the other test can be run.

This device has now been improved upon by using a piston and cylinder with valve which replaces the aspirator bulb and so insures a definite quantity of gas for each test. The test material has been rendered more sensitive so that quantities of the gas as small as .3 of 1 per cent can be shown and fairly accurate analyses to amounts up to 2 per cent made within a few seconds. This latest form of protector has been successfully used in coal and metal mines, in holes and stoke rooms of ships, in garages, and in conduit tunnels. The new detector using the piston gives results which check very well indeed with those obtained by exact analytical chemical methods.

CORROSION

THE American Electrochemical Society devoted much of its recent meeting to a symposium on the corrosion of metals and alloys. In closing this symposium the following summary of the more important points brought out during the two days' discussion was made:

"(1) Iron or steel containing about ¼ per cent copper will withstand atmospheric corrosion better than iron or steel without copper. (2) Iron or steel containing about ¼ per cent copper, when completely immersed in ordinary tap water or in acidulated water, does not resist corrosion as well as pure iron. (3) In boiler practice and in hot water systems (closed systems) the presence of oxygen greatly accelerates corrosion; the removal of this oxygen practically eliminates corrosion. (4) Carbon dioxide in boiler water, together with soluble iron, causes corrosion, and the removal of the CO_2 practically eliminates corrosion. (5) Other elements added to iron in well-defined amounts tend to reduce corrosion, but detailed investigations have as yet not been reported. (6) A satisfactory co-ordination of alloy corrosion research needed but lacking.

"Fink also made the following suggestions for future study and research: (1) A thorough investigation of the surface film involving careful determination of the chemical and of the physical properties of this film—*e.g.*, chemical composition, porosity, tenacity, coefficient of adhesion, coefficient of expansion, etc.—as compared with those of the underlying metal. (2) A careful study of the microstructure of the metal near the surface and a similar study of the metal directly underneath the surface film. (3) The effect of chemical and mechanical treatment on the surface film and the underlying metal. (4) A more complete micrographic investigation of the surface changes of metals during the process of corrosion. (5) A better classification of corrosion phenomena—for example, we must define the limits of moisture and salts in air in which the tests were made. (6) A standard of measure of corrosion."

SMOKE IN SALT LAKE VALLEY

FOR some time certain smelters in the Salt Lake Valley have been under investigation with respect to whether or not the smokes and fumes from them constitute a nuisance to humans and a detriment to crops. These investigations by scientists were undertaken at the instance of a court and as a result of the scientific report the smelters have been permitted to continue operations under conditions as laid down by the scientists. The results have been discussed in *Chemical and Metallurgical Engineering*. It is interesting to note that comparatively few of the analyses show an hourly average of more than one part of sulphur dioxide per million in the samples of air covering some six months during which time upward of four thousand determinations were made.

The average human adult who is already acquainted with the odor of sulphur dioxide will first be able to detect it at a concentration of from 3 to 3.5 parts per million. Those not acquainted with the odor could probably detect it when the concentration reaches from 4 to 5 parts per million and above that figure until 10 parts per million are reached. The action is usually sufficient to cause most people to feel slight discomfort or to cough. Occasionally short whiffs of less than five parts per million cannot be considered a nuisance to any one but continued breathing of air containing even slightly more than 5 parts per million would probably cause discomfort. A few breaths of 10 parts per million would probably be called a nuisance by most people even if this concentration occurred only at considerable intervals.

The entire record of atmospheric tests amounted to nearly six thousand single determinations showing only 19 without concentration of 3 parts or more per million and only one concentration of 6 parts per million. The highest concentration ever found in the district was 7.6.

It is believed that the more sensitive crops when weather conditions are favorable to sulphur dioxide action cannot endure such concentrations as have been found in the field without severe burning and certain remedial steps have been suggested. The principal one of these is that the temperature of the roaster gases before they are discharged into the air should be markedly increased. No measure appears to be anywhere near so efficient as this one in remedying an unfavorable field condition. Should this alone prove insufficient a tall stack will probably have to be erected in addition to heating the gas. The removal of dusts is also an important consideration in which bag filtration and electrical precipitation are employed. The following is quoted:

"The operative measures which should receive attention are:

"1. The bag-filtration of the blast-furnace gases.

"2. The electrical precipitation of roaster dusts and other suspended solids by means of the Cottrell installation, two of the three units of which have been in regular operation

"3. The discharge of the roaster gases, which carry the highest concentrations of sulphur dioxide, at a temperature high above that of the outside air. During the dormant season for plants the temperature of these roaster gases was increased, and incidentally their volume as well, by the delivery of the boiler gases from a neighboring power house directly into the main exit stack. During the season of plant growth the gases were heated by means of coal furnaces near the base of the stack.

"4. The discharge of the gases from roasting operations from a high stack at a point approximately 455 feet above the ground level.

"5. A maximum daily elimination of sulphur from roasting operations amounting to about 100 tons.

"Industrial plants such as this are complicated and sensi-

tive organisms. They will not run themselves. Their successful operation from the standpoint of a high recovery of metal at a low cost of production requires that painstaking attention be paid to all factors which have to do with the efficiency and cost of smelting operations. The situation is not now different in regard to smelter operation in relation to smoke injury. With the recent development of remedial measures having to do with plant operation a new responsibility has been thrust upon the operating staff, a responsibility which calls for no less skilful and painstaking attention on their part.

"It can scarcely be denied that this plant is a potential agent of injury. Allow the filtration bags to deteriorate, reduce the voltage in the Cottrell plant, neglect the measures which have to do with maintaining a relatively high temperature in the exit gases, and a discharge of lead and arsenic in objectionable amounts or of sulphur dioxide under conditions of concentration and temperature which could give rise to serious injury to crops might easily result."

FISH GLUE

No OTHER glue has as many or as varied uses as has liquid fish glue. The best grade of fish skin glue is the only satisfactory one for the production of half-tone plates. It is also used in the production of single line plates for photoengraving work. Fish glues are nearly always used where great flexibility is required, such as in adhesive plasters and book binding. They are sometimes blended with hide glue and considerable quantities find their way into sizing operations. This gives stiffness and yet a degree of flexibility. Dr. T. K. Tressler in the May issue of *Chemical Age* (New York), writes popularly on the manufacture and properties of fish glue in which it is pointed out that the quality of glue prepared from the so-called ground fish which include cod, haddock, cusk, hake, and pollock, is higher and the yield greater than in the case of glue made from most other fish. In general the glue stock is first freed from salt by continuous washing, after which it is cooked slowly and the glue liquor drawn off for further treatment and concentration. Fish heads are treated by a somewhat different process from that used for fish skins and the details are regarded more or less as trade secrets. Fish head glues are generally made opaque with a white pigment. The following properties are given by Dr. Tressler:

"The color of liquid fish glue depends upon the nature of the raw material, the method of manufacture and the clarity of the product. Fish-skin glues, as they are ordinarily produced, are the clearest. Fish waste and fish-head glues are more or less opaque. Most clear fish glues make a dark joint when used with light-colored woods, and consequently much of the liquid glue on the market contains some white pigment. This gives the glue a lighter color and also makes the joint less conspicuous.

"The odor and taste of fish glues depend largely upon the nature and amount of preservatives and essential oils added. Upon heating for some time, the essential oil is driven off and the true odor of the fish glue becomes more apparent.

"The 'speed of set,' or the time elapsing after the application of a coat of glue until the glue becomes a gel, depends upon the gel point and viscosity of the liquid glue, the amount of glue applied, the nature of the wood, and, also, to some extent, upon the humidity of the atmosphere. 'Setting' is caused by a partial withdrawal of the moisture in the glue, thus causing the gelling of the liquid glue. The higher the viscosity and gel point of the liquid glue, the less the amount of glue applied, the more absorbent the surface to which the glue is applied, and the lower the temperature and humidity of the atmosphere, the more rapidly does the glue 'set.'

"At any given temperature and humidity the rate at which the fish glue dries depends upon the source of the glue, the method of manufacture and the salt content. As a rule, fish-skin and waste glues dry more rapidly than fish-head glues, although if the fish skin and waste glues contain an abnormally high salt content this may be reversed.

"The viscosity of liquid fish glue depends upon the source of glue, the method of manufacture, the percentage of dry glue in the liquid glue, the temperature, and the addition of substances other than fish glue, *e.g.*, boric acid, hard glue, phenol and cresol. The addition of boric acid increases the viscosity of liquid fish glue to some extent; whereas the addition of phenol and cresol decreases the viscosity. Small amounts of hard glues, *i.e.*, animal glues, sometimes are added to increase the viscosity.

"Fish-head glues are usually more flexible than skin and waste glues. Glycerin and glucose often are added to increase the flexibility of glues.

"Properly preserved liquid fish glues will keep indefinitely in an air-tight can or well-stoppered bottle. If the glue is stored in a cold room it will gel. This gel melts quickly as soon as the glue has been warmed above its gel point. When liquid glue containing phenol or cresol is put up in tin cans, after a time a black ring is formed around the top of the can where the phenol or cresol has attacked the iron. However, this does not injure the quality of the glue. Precipitates sometimes settle out from poorly prepared liquid glue, but this settling does not injure the strength of the glue."

A COPPER IRON MAGNETIC ALLOY

MR. B. H. BENNETTS in the May issue of *Mining and Metallurgy* contributes the following information concerning a copper iron magnetic alloy found by him in sampling black copper.

"While sampling a shipment of 50 tons of black copper, by the templet method, we found a pig of copper which we tried for two days to drill. It was so hard that it was impossible to drill the hole even with special drills or with the usual press drill. This aroused our curiosity and made us determine to get some of this alloy, which we accomplished by planing away the copper from the segregation. It had the following composition.

	Per Cent
Copper	14.51
Cobal and nickel	2.21
Iron	56.13
Silicon	3.00
Manganese	4.28
Zinc	5.96
Phosphorus	0.21

A shortage of the alloy would not allow further investigation.

"The copper from which this alloy was obtained was made from ores that had a wide range of minerals. Perhaps it will help the reader to say that the copper comes from blast-furnace work making two products—black copper and high-grade copper matte.

"Another curious feature of this copper is the fact that it can be lifted with a magnet. Some samples of the black copper possess this property to a higher degree than others even when the black copper has the same copper content. My attention was first called to this when I tried to clean the copper from any steel that may have entered while drilling the sample for assay purposes. The copper has an average composition of about 92 per cent copper, 2 per cent sulphur, silicon, iron, and, what I consider very unusual, some phosphorus."

SYNTHETIC EMERALDS

THE *Chemical Bulletin* for May reports that "Mr. David Fahlberg of Chemical Engineering, in coöperation with one of his students, Mr. P. C. Kelley, has developed a process for making artificial emeralds. The product seems to be equal in quality to the natural emeralds. It has an index of refraction identical with that of the latter and a hardness greater than that of quartz. The process involves the fusion of crude beryl with a mineralite at high temperatures for several days."

Progress in the Field of Electricity

Summaries and Excerpts from Current Periodicals

By A. Slobod

SOME METHODS OF OBTAINING ADJUSTABLE SPEED WITH ELECTRICALLY-DRIVEN ROLLING MILLS

After outlining the speed requirments of steel rolling mills, disclosing the need in many cases for adjustable speed over a wide range, the paper goes into a discussion of the merits of the Scherbius system of speed control, both single range and double range, in which the slip energy of the main motor is returned to the system as electric energy. A comparison is made with the Kraemer, or synchronous converter system, in which the slip energy is returned to the main motor shaft. The superiority of the Scherbius system is particularly apparent at speeds near synchronism, as over this range the synchronous converter of the Kraemer system becomes unstable. The double range Scherbius system permits of satisfactory operation at speeds below synchronism, at synchronism, and above synchronism. This range is not practicable with the Kraemer system.

The author enumerates the following factors which are to be considered in making a choice of a control system. The more general conditions having a bearing on the choice are: range of speed control, frequency of supply circuit, maximum load at all speeds, production of mill at different speeds, and whether the control is to be automatic.

The double range Scherbius system can readily be designed to meet all except the most extreme speed ranges for both 25-cycle and 60-cycle supply circuits, while the Kraemer system is rather handicapped if the supply frequency is 25 cycles.

When automatic control is required the direct-current systems with motor-generator will usually give better results.

There are, however, a number of important advantages in favor of the double range Scherbius system which must be considered in making a choice. They are: (1) Generally higher efficiency and correspondingly lower power consumption throughout the entire range of control. (2) Frequently a considerable part of the output of a mill may be rolled by the motor without the regulating set, due to the motor speed falling intermediate between the upper and lower limits of the range. This is a very great advantage over the any single range system, since in the event of the failure of the regulating set the high speed at which the roll motor with single range control runs non-regulating limits the production of the mill to small sections while the regulating equipment is being repaired. (3) Its cost is usually lower than that for the other systems when compared on the same basis, *i.e.*, range of speed control over which the maximum roll motor loads may be carried without the roll motor becoming unstable. (4) In common with other systems a large number of speed points may be provided, the power-factor of the main motor may be raised, and the equipment is thoroughly reliable and readily maintained by the operating department.—K. A. Pauly, *General Electric Review*, Vol. 24, pp. 422-432, May, 1921.

WASTE PREVENTION IN THE ELECTRICAL INDUSTRY

During the present industrial crisis some relief from the prevailing depression may be obtained by a careful investigation of the capacity and potential efficiency of the manufacturing plant in the works. Mr. E. V. Chambers suggests several ways of effecting considerable economies.

Of great importance is the steam boiler efficiency. To-day coal is three or four times its 1914 cost, therefore a saving of 10 per cent in the fuel consumption means a considerable annual saving in dollars and cents. The author suggests the employment of intelligent stokers and the carrying out of a complete boiler efficiency test which would expose the defects in the system. He also discusses the importance and the methods of obtaining the proper feed water, the elimination of boiler scale and methods of proper steam piping.

Some electrical manufacturing establishments are equipped with producer gas plant; some of these plants produce tar and sulphate of ammonia, while other plants produce tar only. There has not been any satisfactory demand for this tar, but lately a new form of tar still was introduced, which is of continuous type. The author gives the details of such a plant which gives light oil, heavy oil and pitch. It is quite possible that the products of distillation of producer tar, particularly in the case of the smaller distillation plants, can be utilized in the same works as that which produces the tar. The pitch can be readily converted into a quick drying, hard black varnish, which is eminently suitable for painting castings, pipes, steel plates and other manufactured electrical products. As a general protective paint for the shops and buildings it cannot be excelled. The oils can be utilized for cleaning purposes, particularly for the removal of grease. They also provide for fuel for oil-fired furnaces, and the heavier quality can be easily converted into disinfectant

Many valuable products are wasted by the discharge of liquids used in the electrical and associated industries. Such solutions usually consist of metallic salts with or without the presence of free acid. The electrolytic methods of metal recovery, particularly copper, are, of course, well known. In many other cases the evaporation of surplus water in waste liquor will result in a liquor which, on cooling, deposits crystals which may be recovered for re-use. Care should be taken in regard to the selection of suitable apparatus, particularly where acids are concerned. An excellent material for resisting acid solutions is fused silica. As an example of the recovery of useful products from waste liquors, the author describes an installation for recovering hydrochloric acid and ferrous sulphate from iron wire cleaning or pickling.

Lubricants after a time become so saturated with impurities that they are discharged as waste. By submitting these waste oils to the action of centrifugal force in a rotating centrifugal machine the suspended solids are almot instantaneously removed from the oils, which are discharged in a perfectly transparent condition, quite suitable for re-use. The author describes and illustrates such a centrifugal machine and its modifications for oil recovery from metal turnings and for removing water from lubricating oils.

Quantities of waste mica cuttings are produced in the various sections of the electrical industry. Hitherto these materials have been treated as waste; these cuttings have been examined, and it has been found that on the average they contain the following: mica 70, shellac 24, moisture, 6 per cent. By submitting these cuttings to the ordinary solvent extraction process, it has been found that the whole of the shellac can be recovered, and that the small mica plates free from the shellac can be used for building up large insulating sheets, by using the recovered shellac as the adhesive and paper as the carrying base. In several establishments proposals are under consideration for recovering these materials for re-use in the works. Shellac can also be recovered from insulated paper cuttings.

There is much to be said for the institution of a special inspector whose duty it should be to prevent the various forms of waste. This waste department should investigate every process which could be applied to the recovery for re-use of what has hitherto been regarded as unavoidable waste.—*Electrician* (London), Vol. 86, pp. 619-622, May 20, 1921.

THE ELECTRIC STRENGTH OF AIR UNDER CONTINUOUS POTENTIALS AND AS INFLUENCED BY TEMPERATURE

IN view of the ever increasing transmission voltages, this paper is of importance. It describes a series of experiments on the influence of temperature on corona-forming continuous potentials. The observations have been made on three sizes of wire of diameters 0.0251 cm., 0.0803 cm. and 0.0933 cm., and in each case at several values of temperature within the range of 5° C. and 70° C. At each temperature the pressure has been varied from a value in the neighborhood of that of the atmosphere downward, reaching in the extreme cases the value 6.03 cm. of mercury. Within the range of values reached, as indicated above, the general form of the law of corona, as developed experimentally by a number of other observers, is found to be fulfilled. There are separate families of curves for positive and negative potentials as obtained by varying the pressure for each constant value of temperature.

The critical surface intensity at which corona started upon the wires can be summarized by the relation.

$$E = 39.8\delta + 10.35\sqrt{\frac{\delta}{d}} \text{ for + corona}$$

$$E = 40.3\delta + 11.96\sqrt{\frac{\delta}{d}} \text{ for — corona,}$$

where $\delta = \frac{3.92P}{T}$ P being the pressure of the gas in centimeters of mercury, and T the absolute pressure in degrees centigrade. The observations thus show that under constant conditions as to pressure and temperature a higher value of negative potential than positive potential is required to form corona.

As plotted graphically, the results seem to indicate that when larger wires are used corona appears at the same values of both positive and negative potential. The observations, however, have not been extended sufficiently to show this identity of value. This conclusion is at variance with the observations of a number of other experimenters, in particular with those of W. S. Brown, who concludes that with larger values of diameter of wire negative corona may appear at lower values than positive corona.

The experiments substantiate the empirical laws developed by Whitehead and Peek, although the constants of the equations involved are higher than any heretofore observed. There are indications that at temperatures in the neighborhood of 70° C. a departure from the empirical laws mentioned may set in.—J. B. Whitehead and F. W. Lee, *Journal of the American Institute of Electrical Engineering*, May, 1921, pp. 373-387.

GIGANTIC COLORADO RIVER PROJECT

AN application for a preliminary permit to develop the energy from the waters of the Colorado River has recently been accepted by the Federal Power Commission. The Colorado River is considered the second largest river system in the United States and is unique among the important waterways of the world in its adaptability to control for the four-fold purpose of flood prevenion, irrigation, navigation and power development.

The application contemplates the development of the Colorado River above the Bowlder Canyon project, at Marble Canyon and Diamond Creek, but does not consider the possible power development in the Grand Canyon and other sites along the National Park. The possibilities of the Colorado River project may be summarized as follows: (1) Three thousand feet of waterfall will produce 4,350,000 horsepower, which is equal to one-half of the total hydro-electric power now generated in the entire United States. (2) Flood control will be absolute, reducing the water discharged to that volume which may be safely carried within the natural banks, levees being practically eliminated. (3) Provision will be made for irrigation of an additional 3,250,000 acres, of which one million acres will be above the canyons and the balance below. (4) The storage basin will be over 200 miles in length, impounding more than 40,000,000 acre-feet of water. This will involve the construction of a dam many feet higher than the highest dam in the world. (5) Four hundred miles of the river will be made navigable. (6) The area which may be served with power includes three-quarters of the State of California; the entire States of Arizona, Nevada and Utah, more than one-half of Colorado and New Mexico and one-fifth of Idaho and Wyoming, with possibly large areas in Northern Mexico. (7) Power may be used for the electrification of steam railroads, as well as for commercial agriculture, mining and municipal uses in the entire district. The saving in fuel oil by the substitution of this hydro-electric power will amount to 90,000,000 barrels per year, which is practically the present annual production of the entire State of California. (8) These savings in oil consumption will indefinitely extend the fuel life of our navy and merchant marine, which during the war were of necessity changed from coal to oil burning. (10) Ninety-three per cent of the run-off may be impounded above the storage dam, which will be 500 feet in height. (11) The increase in community wealth by this development will be equal to the total valuation of California for the year 1920.

Below is given a comparison of the proposed Colorado River dam with the present great dams of the West:

Dam.	*Location.*	*Height.*	*Storage.*
Elephant Butte.....	New Mexico	318 feet	2,638,836 acre-feet
Arrow Rock.....	Idaho	438 feet	280,000 acre-feet
Roosevelt.....	Arizona	280 feet	1,367,300 acre-feet
Colorado (proposed) .	Arizona	500 feet	40,000,000 acre-feet

—*Journal of Electricity*, January 15, 1921, Vol. 46, pp. 60-61.

MOUTH-OF-MINE SUPER-POWER PLANTS

ACCORDING to the *Electric Journal* of May, 1921, it was found that the greatest central station development during 1921 has been in the Pittsburgh district, where two super power plants, each designed for an ultimate generating capacity of 300,000 kw., are being placed in service with accompanying extensive increases in transmission lines and substations. Each of these new plants is located on a river affording sufficient condensing water. In addition, they are examples of the mouth-of-mine type of station, as each is located adjoining large coal fields controlled by the power companies. Such locations are desirable from two viewpoints. They eliminate the necessity of paying a profit to coal mining and transportation companies, and afford added insurance of continuity of service, as there is no possibility of interruption of the fuel supply due to strikes or other difficulties on the regular transportation lines. There is also the further possibility of increased economy due to the continuous use of a uniform grade of fuel whose characteristics can be thoroughly analyzed by the operating forces; whereas with purchased coal it is necessary to make use of whatever fuel the railway or water transportation companies are able to deliver.

The central station industry as a whole is vitally interested in the development of these mouth-of-mine super-power plants with their transmission systems and methods of interconnection; therefore, the papers contributed by the officials of the Duquesne Light Company and the West Penn Power Company to the *Electric Journal* of May, 1921, will be found of considerable interest. G. H. Gadsby, vice-president of the West Penn Power Company, discusses the industrial field of his company, while G. G. Bell gives a complete illustrated description of the generating system of the same company. After briefly describing the Connellsville and Windsor stations, the author devotes the major part of his paper to the description of the new Springdale station. In addition to the advantages outlined above, the outstanding features of the recent West Penn

system may be summarized as follows: (1) The labor required for the handling of coal and ashes is reduced to a minimum. (2) Motor drive is used for auxiliaries, thus reducing maintenance and simplifying the station construction. (3) Auxiliaries and sources of power are provided with duplicates, thus eliminating to a great extent shut-downs resulting from troubles with the small equipment. (4) Clean water is provided for service use and distilled water for boiler use. (5) Air for boilers is handled in such a way as to prevent condensation and the formation of vapor in the ash pits. (6) Excessive air is eliminated from the feed water, thus reducing corrosion in boilers as well as in the economizers, if the latter are installed later. (7) Cranes or trolleys have been installed over practically all auxiliaries to reduce to a minimum the time of making repairs. (8) Switching equipment of the highest capacity obtainable is installed. The switches for the electrical equipment were especially designed to give large rupturing capacity, and provisions are made to cut out any switch in case of accident or for inspection. The doors for the oil switches and disconnecting switches are interlocked to prevent an attendant from working on any circuit which is in service.

The power stations of the Duquesne Light Company are described by J. M. Graves. The bulk of the paper is devoted to the new Colfax power station.

TELEO CEMENT FOR MULTI-PART HIGH-TENSION INSULATORS

MANY multi-part insulators fail after four to six years of service. The failure has been traced to cracks which form in the insulator heads. It has been repeatedly shown that these cracks were not occasioned by electrical or external mechanical stresses, but were found to be due to inequality in expansion when heated between the porcelain part and the uniting cement. The stresses thus caused were mathematically investigated by Meyer and Donath in the *Elektrotechnische Zeitschrift*, No. 16, 18, 24 and 45 of 1919. The cracks develop gradually, and do not usually lead to line failures until some abnormal condition arises, or the insulator head is split right through. It is probable that the cement during the first few years of the life of the insulator possesses a certain elasticity, and only attains final hardness after some time.

The Hermsdorff Porcelain Works have now succeeded in discovering a cement mixture which possesses the same expansion coefficient. This has been patented under the name of Teleo Cement, and the process of its manufacture consists in adding to the cement a thinning medium which has a lower coefficient of expansion than porcelain until the required equilibrium is obtained. A thinning of cement to Teleo compound in the ratio of ½ to ¼ is generally sufficient for this purpose. The thinning mediums hitherto in use only gave a slight reduction of the expansion coefficient with increasing thinning. The comparatively high specific gravity of these thinning materials made it impossible to use greater thinning than 1:3 to 1:3, but even greater thinning than mentioned above is quite permissible with Teleo. Its expansion values as compared with those of porcelain and the usual cement are given below:

MEAN EXPANSION VALUES

Material	Observer		
	Laboratory Standard	Hermsdorf Porcelain Works	Freiberg Porcelain Works
Porcelain	3.5×10^{-6}	4.7×10^{-6}	11.0×10^{-6}
Sand Cement	13×10^{-6}	13.1×10^{-6}	4.4×10^{-6}
Teleo Cement	4.0×10^{-6}	5.2×10^{-6}	5.1×10^{-6}

The use of Teleo does away with the necessity of interposing an elastic coating between the cement and the insulator, which practice was resorted to when the danger occasioned by their unequal expansion was first recognized.—Dr. Weicker, *Elektrische Kraftbetriebe und Bahnen*, Vol. 18, pp. 277-278, November 14, 1920.

FUSED BASALT AS ELECTRIC INSULATOR

RECENTLY attempts have been made to melt basalt and to cast it in various forms, and above all to make from it insulators which may with advantage take the place of glass and of porcelain. Basalt is a rock of igneous origin, and can be melted, but hitherto it has not been found possible to make it keep its natural properties during solidification. The difficulties appear now to have been overcome by Dr. Rible de Maurice of Auvergne, who formerly showed, in 1909, the possibility of melting basaltic rock at a temperature of about 1300° C.

The electric resistance of basalt constitutes one of its most noteworthy properties, and if the practical results justify the hopes, founded on the experimental results already attained in two great French industrial laboratories, a great development will take place in the technics of insulation. The tests were carried out on rock fused without special precautions, and also on casts not destined for electrical use, and yet the behavior of the basalt surpassed that of insulating substances usually adopted in electrotechnics. The high value of the electrical resistance of basalt is due to the fact that during cooling a natural layer is formed on the surface of the basalt which differs essentially from that got in the case of porcelain in that it extends progressively into the substance of the material and does not undergo foliation. The formation of this natural envelope results from a modification of the crystalline structure of the basalt in the neighborhood of the boundaries of the casting. Other precious characteristics of this fused rock are its resistance to the effects of varying temperature, the possibility of forming during fusion the necessary metallic armatures and its greater resistance to deterioration.—*Ingegneria Italiana*, December 2, 1920—through *Technical Review*.

THE RUSS ELECTRIC FURNACE

MR. E. FR. RUSS describes his new electric furnace in *Elektrotechnische Zeitschrift* for January 13, 1921, p. 34. It can be employed for all purposes requiring electrically generated heat, including the melting of copper, aluminum and other similar metals and alloys, as well as for melting and refining of iron and steel and for the production of various ferro-alloys and special steels. In the usual form of the arc furnace there is a creeping upward of the electric arc; this is prevented in the Russ furnace by the design of the upper electrode. Instead of being in the form of a carbon rod or cylinder of equal diameter above and below the furnace crown, it terminates in a head which is much larger than the shaft which passes through the furnace roof, and this terminal of the electrode nearly covers the whole area of the furnace bed. This arrangement also helps to retain the heat generated by the arc in the metal by checking the radiation toward the furnace crown. The life of the furnace roof is thereby greatly increased, with a considerable saving as regards renewals and maintenance cost. The opening in the furnace roof through which the electrode shaft passes can also be made much smaller with the Russ type of electrode, and the action of the hot furnace gases upon the material of the shafts at this point is consequently much diminished. The electrode shaft is covered with a heat-resistant covering which serves still further to diminish the heat losses at this point. The distance between the electrode head and the surface of the bath is also much smaller than in the usual type of arc furnace, and a more uniform and steady heat effect is thereby produced. The shaft of the electrode is of copper; therefore, the resistance losses are far lower than with the ordinary carbon or graphite electrodes. This new furnace is being manufactured by the firm "Rheinmetall" in Düsseldorf. The article is accompanied by one drawing of a 150-kg. furnace designed for operation with single-phase current.

Survey of Progress in Mechanical Engineering

Prepared Under the Auspices of the American Society of Mechanical Engineers

"SILENT RECORD" INTERNAL COMBUSTION ENGINE

DESCRIPTION of an engine built by a British concern and working on somewhat unconventional lines. Essentially the engine is a two-stroke cycle. Fig. 1 shows the arrangement of a two-crank engine. The cranks are at 180 deg. to each other and are connected to the charging pistons C and D. These large pistons carry above them four working pistons A_1, A_2, B_1 and B_2. As the working pistons are about half the diameter of the charging pistons, the net area of the latter is about equal to that of the former. There is also a piston valve worked by the eccentric E. The action is as follows: On the down stroke the pistons C and D draw in explosive mixtures which are compressed on the up stroke and delivered to the inlet ports at the bottom of one of the working cylinders, the exhaust escaping through exhaust ports at the bottom of

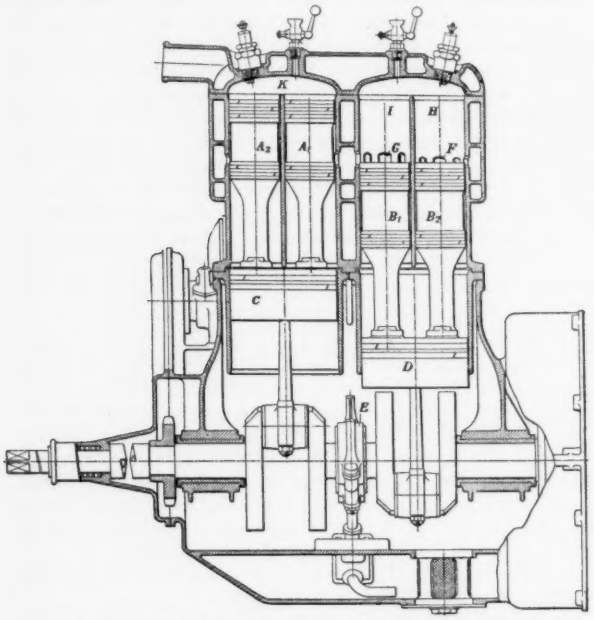


FIG. 1. "SILENT RECORD" TWO-CYCLE ENGINE OF UNCONVENTIONAL DESIGN

the other cylinder. The charging cylinders do not supply the working cylinders directly above them but those above the opposite crank, *i.e.*, C supplies B_1, B_2 and D supplies A_1, A_2.

Taking Fig. 1 in the position shown, the pistons A_1, A_2 have compressed the working charge into the combustion chamber K ready for firing. The charging piston C has also drawn in a charge and slightly compressed it in the space between the pistons. The pistons B_1, B_2 have finished their working stroke and B has fully uncovered the exhaust port G, while B_2 slightly later uncovered the inlet port F. The piston valve now allows the charge compressed by the charging piston C to flow through the inlet port F into the cylinder H from which it flows across the combustion chamber and down the cylinder I, pushing the exhaust out of the port G in front of it.

The charge in the combustion chamber K is now fired, and the pistons A_1, A_2 descend. As they do so the piston valve puts the space above C into communication with the carburetor and allows new mixture to be drawn in, while it puts the space above D into communication with the inlet port uncovered by the piston A_2. The charge in H and I is compressed and fired at the top of the stroke, while the piston A_1, A_2 uncover exhaust and inlet ports corresponding to F and G, and the cycle recommences.

As compared with the ordinary two-stroke cycle engine, the advantage of the design described above lies in the fact that crankcase compression is not used and also that positive distribution of the mixture to the charging cylinders is secured. It is also claimed that a more complete stratification is secured.

The engine shown has four working cylinders equivalent to two cylinders 3 in. x 3½ in. and develops 10 b.hp. at 1600 r.p.m. —*Engineering*, Vol. 111, No. 2888, May 6, 1921, p. 565.

A MODERN AIR LIFT PUMPING PLANT

BY JOHN OLIPHANT

DESCRIPTION of an air lift pumping plant installed by the Philadelphia & Reading Co. at Telford, Pa. In this case the problem was to deliver the water from an artesian well into an elevated tank located at a distance from the well and to control the operation as to starting and stopping from another distant point, and at the same time to control the cooling water supplied to the water-jacketed air cylinder of the compressor, the pumping being at the rate of approximately 100 gallons per minute.

The well was equipped with a 3-inch air lift foot piece having outside air connections and a multiple orifice mixing tube located centrally in the mixing chamber and discharging the air through a number of small openings into a relatively thin sheet of ascending water. It is claimed that this design secures a complete emulsion of air and water in the foot piece.

In the pit around the low head and connected to the reduction pipe was located a Sullivan cyclone booster 30 inches in diameter by 30 inches high. The combined air and water was discharged into this booster and separator near the top and at one side at a tangent to the periphery under high velocity from the well, causing it to swirl and thus effect a perfect separation of the air and water. The water leaves the separator at the bottom, also at a tangent to the periphery and the air passes off at the top. The air pressure in the booster is controlled by a valve set to maintain the pressure required by the head against which the booster is discharging, this head being caused by friction in the pipe (536 feet of horizontal run, a rise of 14 feet from the booster to the base of the elevated tank, and the elevation of 66 feet). The arrangement of the compressor, air receiver and well is shown in Fig. 2. In addition to this the original article contains an interesting drawing showing the pipe layout for the air lift.

The regulation as installed here is of considerable interest. As it was required to control this plant from a distant point, it became necessary to unload the compressor when it stopped, and in starting, to permit the compressor to get up to speed before the load was thrown in. This was accomplished by means of a flyball governor on the compressor that acted as an unloader when it was at rest, and did not admit air to the compressor until the speed had elevated or extended the controlling balls. It was also necessary to shut off the cooling water to the air cylinder when the compressor was stopped, and turn it on again when started. This was accomplished by placing a balanced solenoid valve of the normally closed type in the cooling water line controlled from the starting control at the switchboard.

A push button, together with a relay, were located at the pumping station. In the railway station, 3,600 feet from the

plant, another push button was installed and an electric-connected pressure gage at the base of the plant tank was connected to a bell at this latter point to give the alarm when the tank was full of water. Provision was then made for starting and stopping the plant either at the pumping station or at the station 3,600 feet away. As the compressor is of enclosed, splash lubrication type, and is equipped with

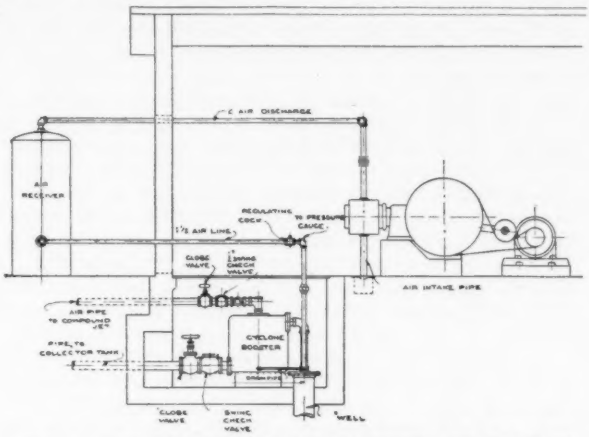


FIG. 2. THE COMPRESSOR, AIR RECEIVER AND WELL IN THE AIR LIFT PUMPING PLANT OF THE PHILADELPHIA & READING CO. AT TELFORD, PA.

a McCord force-feed lubricator, it is safely manipulated from the station, where a push of the button by the station agent starts the pumping and when notified by the ringing of the bell that the tank is full another push stops it. The air and water lines were laid so as to drain back into the booster, and a small connection with a partially opened valve was made from the bottom of the booster back into the well, so that all connections drain to obviate freezing in cold weather during idle periods.

A record is given of a test run from which it would appear that with a total head of 149 feet the theoretical horsepower required was 3.55 hp. while the actual electrical input was 12.5 hp. which would indicate an overall efficiency (wire to water) of 28.5 per cent.—*Railway Maintenance Engineer*, Vol. 17, No. 5, May, 1921, pp. 172-174.

EXETER ROTARY PUMP

THE Exeter rotary pump built under the Feuerheerd patents is an application to pumps of the principle of the square hole drilling device in which a triangular bit functions inside a restraining square formed of equal size. The irregular spaces increasing and diminishing in volume as the two rotate together are utilized to admit and eject the fluid.

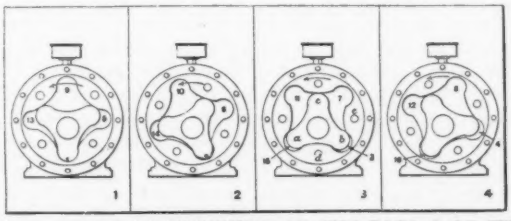


FIG. 3. CYCLE OF MOVEMENT OF THE ROTORS OF THE EXETER PUMP

Fig. 3 shows the cycle of movement of the rotors of the Exeter pump. One of the interesting features is that the pump is self-priming. It has, of course, no valves. As there are no surfaces rubbing against each other, this pump may be used to handle dirty and gritty water. The capacity of the pump per revolution is equal to three times the volume of space 9 in column 1 of the illustration.—*The Nautical Gazette*, Vol. 101, No. 19, May 7, 1921, pp. 597 and 609.

ACTION OF INTERNAL STRESS ON TOOL STEEL

By J. NEIL GREENWOOD

DISCUSSION on the failure of metals through the action of internal stress irregularities, with special reference to tool steels. The opinion is advanced that internal stress falls into two main classes, namely, distortion of the equilibrium space lattice by cold working, and suppression of an allotropic change as a result of rapid cooling. In the case of pure iron the change from the α form to the γ form is accompanied by a volume contraction of about 0.5 per cent. With the introduction of carbon another change takes place due to solution of iron carbide at and above 725 deg. cent., accompanied by transformation of the solvent iron to the γ state. This is associated with a volume change, which increases with the carbon content. The expansion due to solution of the carbide, however, does not equal the contraction due to the formation of γ iron even with 1.5 per cent carbon present. With 0.8 per cent carbon or more, the contraction is approximately half of that due to the α to γ transformation in pure iron. The compressibility of steel is calculated as 0.62×10^{-6} per megabar, or 0.945×10^{-4} per ton per square inch. In other words a pressure of one ton per square inch causes a diminution in volume of 0.009 per cent; so that an external pressure of at least 50 to 60 tons per square inch would be required to cause a contraction equal to that resulting from the transformation from the α form to the γ form. A contraction of volume also occurs when α cementite is transformed into β cementite at about 200 deg. cent., but this contraction is very slight and only becomes appreciable in comparison with the other changes, when there is about 2 per cent carbon present. In the process of hardening carbon steel internal stresses may be caused by the retention of iron in the γ form with a tendency to revert to the α form by the suppression of the carbide phase change when this compression is accompanied with decrease in volume, and by the completion of the carbide phase change in the interior of the mass.—*Engineering*, Vol. 111, No. 2887, April 29, 1921, pp. 535-537.

PNEUMATIC TRANSMISSION OF MESSAGES ON WARSHIPS

DESCRIPTION of pneumatic dispatch equipment extensively used on British warships.

Fig. 4 shows diagrammatically the layout of a ship installation. There are two electrically-driven pumps situated respectively in the fan room and on the lower deck, and controlled from the main and auxiliary wireless telegraph offices. Each valve has a reversing valve fitted above the silencers, by means of which the message pipes are put into connection either with the suction or pressure sides of the pipe, so that the message carriers may either be drawn from the far end of the tube or propelled in the opposite direction.

On the suction side there is an intake consisting of a simple bell-mouthed casting covered with wire gauze at the open end. The silencers are galvanized steel vessels with internal baffle plates and are introduced to eliminate the pulsations of the air and deaden the sound of the exhaust.

The pumps in smaller installations have a vertical single-acting cylinder, 6 inch bore by 4 inch stroke, running at 600 r.p.m. and driven by a 1¼-h.hp. motor. In larger installations horizontal pumps of a somewhat different type are used.

The brass tubes in which the condensers or carriers travel are of 1½ inch internal diameter and are made in lengths of about 15 feet, the bends being of standard radius of 5 feet with a minimum radius of 1½ feet.

The type of carrier employed has an end pad of hard felt and a body of fiber. A light steel finger spring is fitted inside to prevent the papers being carried from falling out. The felt pad fits the tube and forms a piston against which the air pressure works.

The layout of Fig. 4 shows that a single transmission tube is carried from the installation in the main wireless telegraphy

room to the bridge, and that tubes are carried from the auxiliary wireless telegraphy room to the main wireless telegraphy room and the bridge. On the tube leading to the bridge there is an intercepter in the signal distributing office which consists of a sliding sleeve with a celluloid window and a valve or stop worked by a handle so that the carriers

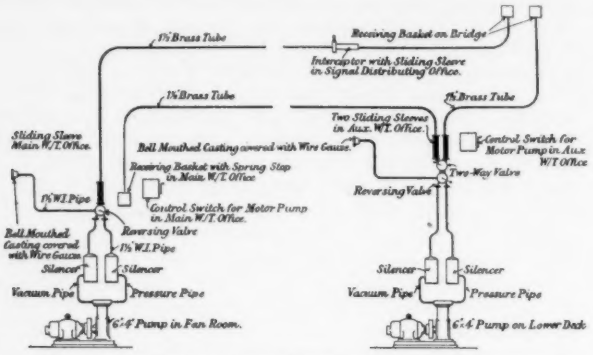

1½ Brass Tube
Receiving Basket on Bridge
Interceptor with Sliding Sleeve in Signal Distributing Office.
1½ Brass Tube
1½ Brass Tube
Two Sliding Sleeves in Aux. W/T Office.
Sliding Sleeve Main W/T Office.
Bell Mouthed Casting covered with Wire Gauze.
Control Switch for Motor Pump in Aux. W/T Office
Receiving Basket with Spring Stop in Main W/T Office
Two-Way Valve
Reversing Valve
1½ W.I. Pipe
Control Switch for Motor Pump in Main W/T Office.
Bell Mouthed Casting covered with Wire Gauze
Reversing Valve
1½ W.I. Pipe
Silencer
Silencer
Silencer
Silencer
Vacuum Pipe
Pressure Pipe
Vacuum Pipe
Pressure Pipe
6"-4" Pump in Fan Room.
6"-4" Pump on Lower Deck

FIG. 4. PNEUMATIC TRANSMISSION OF MESSAGES ON WARSHIPS (DIAGRAMMATIC LAYOUT)

may either be stopped or allowed to pass through as desired.

The whole of this pneumatic dispatch arrangement is simple and there is little or nothing to get out of order. It is very quick in operation and the time of transit on the longest tube on board ship is rarely more than 10 seconds. (The speed at which the carriers travel in the tubes is approximately 30 m.p.h.) The original article describes also some of the secondary details of this apparatus. *Engineering*, Vol. 111, No. 2888, May 6, 1921, pp. 548-549.

PULSATING WINGS FOR AIRPLANES

By Harry Harper

An attempt to describe the theory and action of the wing claimed to have been invented by Prof. Raimund Nimfuhr of Vienna. It is stated that a full-sized load-carrying airplane is to be built and that the venture is to be financed by American capital.

In the Nimfuhr method an attempt is made to imitate the pulsating action of an insect's wing and it is stated that the Nimfuhr wing is hollow with air bags inside, the underneath section of the wing taking the form of a flexible membrane. This membrane can be set beating or pulsating by the action of pneumatic pumps which alternately fill or empty the air bags in the wing. These pulsations, immensely rapid, act powerfully on the cushion of compressed air which, in flight, is formed beneath the plane. It is claimed that these pulsations would not only sustain but also propel a machine forward through the air, the air screw being eliminated entirely.

The Nimfuhr wing is also provided with flexible extremities at both ends, which, by pneumatic action, can be made to extend or contract in imitation of the "reefing" of a bird's wing. (*Motor Transport*, Vol. 32, No. 843, April 25, 1921, pp. 442-443.) *It may be mentioned in this connection that an unsuccessful attempt to build an airplane with pulsating wings was made in 1908 by a Russian engineer, Tatarinoff, working with the Russian War Department. In that case the pulsations of the wing were to be produced by means of springs.* —Editor.

Progress in Mining and Metallurgy

Abstracts of Papers and Recent Articles

Prepared Under the Auspices of the American Institute of Mining and Metallurgical Engineers

GEOLOGY OF THE NAMMA COAL FIELD, BURMA

By Edel Moldenke

The most promising lignite deposits are in the Namma field, in the Northern Shan states of Upper Burma, about 30 miles south of Lashio, 750 miles north of Rangoon. The most promising part of the basin is about 11 miles long and 5 miles wide, with an area of 50 square miles. The field was first explored in 1891. In 1906 a few test pits were put down and an unsuccessful locomotive test was made by the Burma railway from coal taken near the surface. In 1918-1919, a careful exploration made by the writer, for the Burma Mines, Ltd., resulted in proving considerable of the bed which was opened in 1919 by a double-track slope to a depth of 500 feet; it has since been extended to 750 feet. The outcrops are few in the gently sloping country, with about 10 feet of soil cover; but sufficient outcrops were found along the main stream of the Namma River and on small side streams to prove the location of the coal.

The basic rock of the coal field is limestone of Devonian age, the coal being found in overlying Tertiary beds. The limestone is gently folded but badly shattered in some places.

There are two main beds: the upper one from 10 to 15 feet thick, with an average of 12 feet, has a characteristic parting about the middle from 3 to 6 inches thick; the lower bed ranges from 19 to 40 feet, is of uniform character from top to bottom and has an average thickness of about 21 feet in the area examined. The stratum between the two beds is loosely cemented sandstones and clays, and maintains a thickness of 21 feet. Below the lower bed is a layer of quicksand 2 feet thick, which is heavily charged with water.

The coal is badly weathered at the surface, but below surface influence it is a lustrous bright black lignite with a dark brown streak, having a specific gravity of 1.4 to 1.5. The coal breaks with a conchoidal fracture. On exposure, it loses some moisture and breaks into cubical fragments. It burns with a bright flame and strong odor and yields a light coke.

The writer considers 50,000,000 tons of coal in the lower and 30,000,000 in the upper bed, a very conservative estimate of the contents of the proved portion of the basin. As no mining has been done, the possible percentage of recovery has not been determined.

The mines would probably be worked by Chinese labor from Yunnan, as the local inhabitants, the Shans, fail to see the necessity for hard labor, and do not form a reliable working force. Owing to the low efficiency of labor and the costly transportation, the cost of coal will be high, but, it is believed, considerably less than that of imported coal.—(Abstract of Paper to be presented at the Wilkes-Barre meeting, September, 1921.)

FLOTATION OF PYRITE

By Walter S. Morley

This paper is a record of the first of a series of tests on sulfide minerals to be made by the metallurgical department of the University of California. The purpose of the tests recorded is to determine the action of standard oils, oil mixtures, and modifying agents on the flotation of pyrites. The commercial value of pyrite was not considered. Of the many factors affecting flotation, only two—the oil and the other agent used—were made variable.

TESTS ON MOUNTAIN COPPER PYRITE

In the tests on Mountain copper pyrite, twenty-two standard flotative agents were used. The pyrite was crushed to pass a 100-mesh Tyler screen and was mixed with clean siliceous sand in the proportion of one to three.

The test samples gave the following analysis: iron, 10.59 per cent; sulfur, 11.95 per cent; copper, 0.16 per cent; zinc, 0.32 per cent; insoluble, 73.60 per cent. By calculation, the pyrite content was found to be 22.40 per cent.

Some of the flotative agents, particularly those containing viscous ingredients like coal tar, practically failed in this investigation. When 0.15 per cent of sulfuric acid was added to the four flotation agents that gave the best results in the preceding tests, there was a tendency to produce a cleaner concentrate and a higher recovery and to decrease the amount of oil necessary. The addition of sodium hydroxide has produced beneficial results. Lime is not a desirable addition. Bleaching powder acts like sodium hydroxide and sodium sulfide; it is essentially a gangue lifter.

Flotation agents that gave good results on fresh material, gave poor results on material that had been exposed to the atmosphere for six months.

TEST ON CHESTATEE PYRITE

These test samples were prepared in the same manner as those described and gave the following analysis: iron, 11.34 per cent; sulfur, 12.07 per cent; copper, 0.37 per cent; zinc, 0.40 per cent; insoluble, 70.65 per cent. By calculation, the pyritic content was found to be 23.60 per cent. Pentarco No. 350 gave a higher grade concentrate of pyrite, but a lower recovery than with Mountain copper pyrite; the recovery of copper is higher and that of zinc lower than before. Pentarco No. 400 gives almost the same grade of pyrite concentrate, but a higher recovery than with Mountain copper pyrite. The addition of sulfuric acid gave better results than the use of these flotation agents alone. But on the whole, the results of these tests, while similar to those obtained when testing Mountain copper pyrite, were not quite so good.

TESTS ON SULPHUR MINING AND RAILROAD PYRITE

These test samples, which were prepared in the same manner as the others, gave the following analysis: iron, 8.84 per cent; sulfur, 7.79 per cent; copper, 0.13 per cent; zinc, 0.21 per cent; insoluble, 81.44 per cent. By calculation, the pyrite content was found to be 14.20 per cent. The results obtained compared favorably with those obtained in the preceding tests. In every case but one, the recovery of pyrite was over 90.0 per cent. The addition of sulfuric acid was of no advantage.

SUMMARY OF RESULTS

Of the twenty-two standard oils and oil mixtures, only four, Pentarco Nos. 350 and 400, acid sludge, and mixture A gave recoveries above 90 per cent, when tested on Mountain copper under the conditions given. Considering both concentration and recovery, mixture A gave the best result. The recovery of zinc, as sphalerite, is generally higher than that of either pyrite or chalcopyrite, using the standard oils and oil mixtures tried.

The recovery of copper, as chalcopyrite, is variable; the highest recovery (93.2 per cent) was obtained by the use of X cake and X ylidine in alkaline solution. This reagent at the same time gave much lower recoveries for both pyrite (47.9 per cent) and zinc (71.0 per cent), thus indicating possibilities of differential or selective flotation.

Sulfuric acid was by far the most efficient of the modifying agents used; the increase in the concentration of pyrite is particularly noticeable. Sodium silicate was somewhat effective in causing a differential or selective flotation of copper, as chalcopyrite from pyrite by keeping pyrite from floating. Sodium hydroxide and sodium sulfide gave, in most cases, a distinct separation of sphalerite from chalcopyrite; *i.e.*, a high copper and low zinc by suppressing the flotation of sphalerite.

Tarnish on the Moutain copper pyrite tended to prevent flotation. Sulfuric acid was the most effective modifying agent in removing the tarnish and giving good recoveries of the pyrite, copper, and zinc.

The finer the material the greater is the percentage of recovery; the pyrite should pass at least a 170-mesh screen in order to get efficient flotation under the conditions of the tests.—(Abstract of Paper to be presented at the Wilkes-Barre meeting, September, 1921.)

UNDERGROUND MINE DEVELOPMENT, ITS DEFINITION AND VALUATION

By JOHN B. DILWORTH

THE word "development," as used in connection with mining, is a rather general term and in most instances must be qualified or explained before the exact thought in the mind of the user is made clear. But, as a rule, when the development of an individual mine is spoken of the idea in mind is the system of underground workings by means of which the mineral is recovered and transported to the surface. It is this character of development that is considered in this paper.

The discussion is confined to the ordinary room-and-pillar system of mining practically horizontal coal seams that is used in most bituminous coal mines in this country, and to only two phases of this subject; *viz.*, what is properly included under the head of "development" as it appears on the books of a coal company or the inventories of an examining engineer, and how its "value" should be determined by the accountant or engineer.

Perhaps the majority of mine accountants would agree that the mine development account is that capital account which shows the extraordinary expenditures incurred in opening and expanding the underground workings of a mine until it has reached its normal production. The expenditures are those made for shafts, slopes, rock tunnels, drift mouths and such relatively permanent work; also payments over and above ordinary mining costs made for driving entries, air courses and breakthroughs; for timbering, grading haulageways, etc. Yet this definition does not express the universal practice and is subject to various interpretations.

One common departure from this rule is with regard to the period of the mine's operation when the development account should be closed. Some think this account should be closed not when the mine has reached its normal production but when the returns from the coal produced equal the cost of production. Others prefer to limit the development period to the time when the output has reached a certain percentage (say 25 or 50 per cent) of the anticipated normal production. But the best practice would seem to be to continue the development account until the mine is prepared to afford a production that it may reasonably be expected to maintain over a period of years.

ITEMS THAT FORM EXTRAORDINARY EXPENDITURES

It is generally agreed that the total actual cost of such work as the sinking of shafts, driving of rock slopes or tunnels and construction of drift portals should be charged to the mine development account, as it is a more or less permanent nature comparable to plant construction and installation. These will be referred to hereafter as Class A expenditures.

But when preliminary work intimately connected with the recovery of coal is involved and where the outlay is partly or wholly offset by income, from the sale of this coal, opinions differ as to how much of the expense is properly chargeable to development. Examples of such expenses are, compensation over and above the regular room rate paid to miners for coal from narrow places such as entries, air courses, cross cuts, and room necks; yardage paid for removing rock, bone, or other non-commercial material from roof or floor of the seam in such places in the regular course of mining to provide suf-

ficient head room; extra payments made for driving entries through clay veins or local rolls, etc. These will be called class B expenditures.

Expenses of an intermediate nature between classes A and B are those of grading haulage entries by cutting through rolls in roof and floor; driving entries through zones of thin, impure, or faulty coal; timbering or otherwise securing a safe roof in entries; constructing brattices, overcasts and air doors. Some operators maintain that the development account should be charged with the entire cost of all such work during the development period and credited with receipts from the sale of coal produced, the difference being the cost and value of development. While this method, in a sense, shows the net cost of the work, it will rarely give its true value, for the selling price of the coal varies with market conditions and bears no direct relation to the value of development. Thus, the development account of a mine opened during a period of high coal prices would show a much lower net charge than this account for a similar mine opened when coal was cheap.

Another method charges to development all payments above the room rate made for narrow work, yardage and other operations in class B. It assumes that all mining expenses over and above the cost of room coal during the development period are for additions or improvements to the mine and therefore chargeable to this division of the capital account. This method, while preferable to the preceding one, allows too great a profit on the tonnage sold by placing its cost at that of the cheapest coal that the mine affords.

The best method seems to be to charge to the development account all work in classes A and B during the period of development and credit it with the normal cost of the coal recovered. The debit balance, when the development period is passed, will be the net cost or value of mine development. By *normal cost* is meant the product of the number of tons recovered multiplied by the average cost of producing a ton of coal when the mine is in full operation, comprising expenses of mining, dead work, hauling, tipple, ventilation, drainage, power, superintendence, and such items as constitute regular expenses of mining. It may be claimed that this practice involves the use of an estimated figure, normal cost per ton, in the case of a new mine. But this is not a serious objection for, in the case of most coal mines, an experienced engineer or operator, given the wage scale, can estimate quite closely what this cost will be.

CLASSIFYING AND VALUING MINE DEVELOPMENT

Some accountants give a fixed value per foot to the main entries alone or to special parts of them; others classify the entries according to their condition and use and assign a separate per-foot value to each class; still others calculate that it costs a certain amount to develop a working face and give the product of this figure by the number of active faces as the value of the mine's development.

A better plan is to use the method of estimating the excess cost of underground work over normal mining costs for the period of development; *i.e.*, until the workings have sufficient active faces to afford the mine's normal output.

SUMMARY

The period of a mine's development terminates when the active workings are sufficiently large to afford the normal output for which the opertion is designed. The development account should show on the debit side the expenditures incurred in opening and expanding the underground workings during the development period, and on the credit side the normal cost of the coal produced during that period and a proper depreciation allowance. The value of development at a given period is the debit balance of this account; *i.e.*, the net cost or extraordinary expense of underground work incident to establishing a mine on its normal production basis, less depreciation based on the remaining recoverable coal.—(Abstract of Paper to be presented at the Wilkes-Barre meeting, September, 1921.)

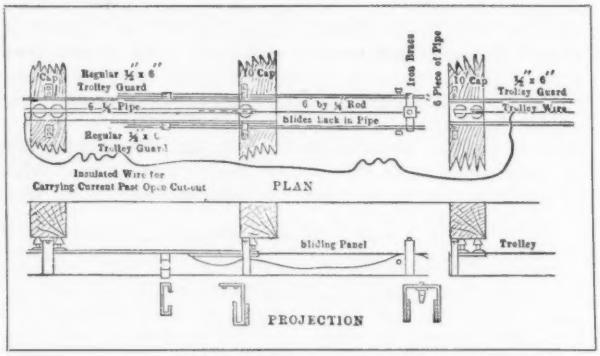
SAFETY CUT-OUT FOR TROLLEY WIRES AT LOADING CHUTES

By E. D. GARDNER

TROLLEY lines used in connection with electric haulage in mines are a source of danger. Usually the wires in metal mines are sufficiently guarded to prevent men from touching them with their persons or with pieces of steel which they may be carrying on their shoulders, while walking along the level, but it is difficult to guard effectively the wires at loading chutes along the haulageways, and in spite of safeguards, chute trappers have been electrocuted through loading bars accidentally touching the trolley line.

To overcome this danger the Calumet & Arizona Mining Co., at Lowell, Ariz., formerly used a hinged V-shaped trough made of 1 inch by 6 inch lumber, that was dropped over the wire in front of the chute, when the cars were being loaded. This arrangement interfered with the easy operation of the chute and a cut-out device for the trolley line was devised by W. R. Gibson, chief electrician for the company. This cut-out is efficient, easily constructed and does not interfere with the operations at the chutes or with the motors operating on the same level. When the cut-out is open the electric current is carried past the gap by an insulated wire on the opposite side of the drift. A hinged board drops down over the ends of the trolley guard when the slide is open and prevents anything touching the live wires. About ninety of these cut-outs are now in use in the mine.

The levels under the stopes are timbered with drift sets placed 5 feet apart, and the loading chutes take up the space



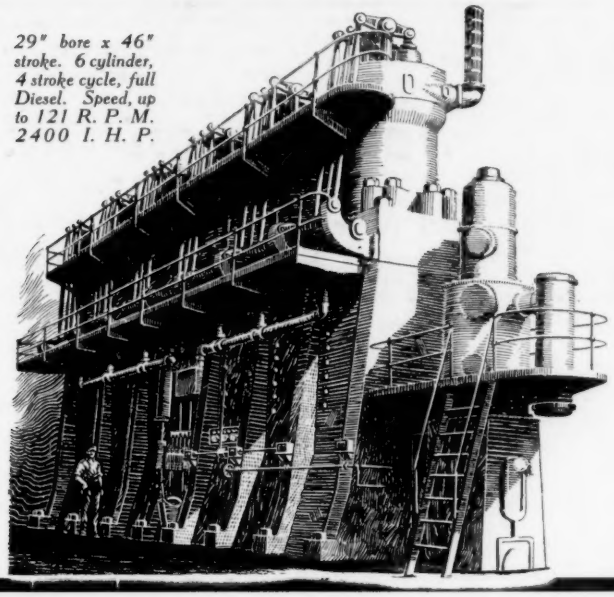
TROLLEY SAFETY CUT OUT

between two sets. All trolley wires in the company's mines are carried 6½ feet above the rails and guarded by two ½ by 6-inch boards placed on either side of the wire.

The cut-out is simple in construction, and consists essentially of a section of ¼-inch rod that slides back into a 6-foot length of ½-inch pipe, both of which are a part of the trolley line.

When closed, one end of the rod remains in the long pipe, at the set back of the chute, and the other end fits into a 6-inch length on the set ahead, and both ends have enough bearing to make proper electrical contact. Standard electric equipment is used in the mine and as the trolley-wire hangers will not fit the ½-inch pipe, a ¼-inch rod is welded on top for clamping it in place. The motors run past the cut-outs with no interference.

When the cut-out is closed, it is guarded by two ½-inch by 6 inch boards, as elsewhere. The free end of the rod and guard boards are fastened together by an open rectangular piece of ½-inch by 3-inch iron. The trolley rod is hung from the top of the iron by insulated hangers, and the guard boards are bolted to the sides. The boards slide back in brackets outside of the regular guards. Occasionally, in wet places, enough current leaks through the insulators to the boards of the cut-out to shock a man, and, to prevent this, insulated knobs are placed on both guard boards for handling.—(Reports of Investigations, Bureau of Mines, Serial No. 2248.)



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